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Effects of Form Perception and Meaning on the Visual Evoked Potential with Author's Update

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14. ABSTRACT

Visual evoked responses (VER) from different interpretations of reversible figures, simple geometrical forms, and consonant-vowel-consonant (cvc) trigrams with differently ordered consonants were studied over a 2-year period in three adult human subjects. Stimuli were all black line figures subtending less than 2 degrees, seen against a white, square, 10-degree background and presented in random order with a random interstimulus interval. VERs were obtained from six active electrode sites. VER wave forms resulting from unlike stimuli or stimulus interpretations were defined as disparate when amplitude differences of one or more frequency components were greater than the amplitude differences from replications of the same stimulus or stimulus interpretation. Results were then placed in binary arrays for within and between subject comparisons. Distinctly different VERs were found for the different interpretations of reversible figures. This was interpreted as resulting from perceptual, rather than sensory processes. Continued on next page.

15. SUBJECT TERMS

event-related potential (ERP), positron emission tomography (PET), functional magnetic resonance imaging (fMRI), binocular rivalry, ambiguous figure resolution, masking, Visual Evoked Response (VER), Traumatic Brain Injury (TBI), affect, cvc trigrams

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14. Abstract

VER differences were also found resulting from differences in simple geometrical figure forms and angular subtenses. These differences were all attributed to sensory processes. VERs did not distinguish between trigram meanings based on changes in consonant order, but may distinguish between meaningful and nonsense trigram classes.

Author's update

In this brief introduction I will discuss the purpose of the research presented here, the context in which it occurred, and the future applications of the techniques employed. Why, then, look at visual evoked potentials resulting from ambiguous figures and consonant-vowel-consonant (cvc) trigrams?

When I was beginning my education in psychology in the 1960s, behaviorism was dominant. I remember going to conventions on the Sexual Behavior of the London Sewer Rat in Albuquerque, NM and on Short-Term Behavioral Therapies in Chicago, IL, where a laboratory was maintained for running rats on reinforcement schedules paralleling those of human patients in order to model and work through particularly difficult therapy problems. Behaviorism, which started with I. P. Pavlov, recipient of the 1904 Nobel Prize in Physiological Medicine, became a growing rebellion against introspection and Gestalt psychology by individuals like, J. B. Watson (1913a, 1913b), C. L. Hull (1934, 1930), A. Salter (1952, 1961), J. Wolpe (1958), and H. J. Eysenck (1952), culminating in the work of B. F. Skinner (1953, 1969) and his followers. At the core of the conflict was the ability to directly observe, objectively measure, and replicate events. Results of introspection in Gestalt psychology, as practiced by M. Wertheimer (1924), W. Kohler (1992), K. Koffka (1935), and psychoanalytic talk therapies associated with S. Freud (1995, 1990), gave results that were less accessible to scientific method. In short, behaviorism was an effort to make psychology more scientific by abandoning efforts to describe what went on in the *black box* behind our eyes.

As with behaviorism's reaction to introspection, there was a developing reaction against behaviorism. Researchers tried to find ways to describe and infer the nature of higher order, hidden, brain processing of information, memory, attention, and eventually consciousness itself. Between 1950 and 1970 there was a resurgence of interest in cognitive science paralleling the development of new technologies in the neurosciences and in electrophysiology. U. Neisser (1967) called this renewed interest cognitive psychology and emphasized use of scientific methods for investigating the *black box*.

D.O. Hebb (1949) developed neurological theories regarding post-sensory information processing and higher order thought. Although he was limited by the technology of the times, the growing knowledge about the electrophysiology of the brain began to open avenues for relating brain function to sensory stimulation. J. C. Eccles, A. L. Hodgkin and A. F. Huxley (1952) shared the 1963 Nobel Prize in Physiology or Medicine for their work determining the mechanisms underlying electrical conduction in nerve cells. D. H. Hubel and T. N. Wiesel (1974, 1965, 1962, 1959) shared the 1981 Nobel Prize for their work on recording the activity of single brain neuron reactions to visual stimuli.

In 1969, E. Donchin and D. B. Lindsley (1969) organized a conference on the emerging use of average evoked potentials (AEP), a technique for isolating the electrical activity of the brain associated with a stimulus presentation. In 1972, D. Regan wrote a classic book on the use of AEPs in psychology, sensory physiology and medicine. Looking into the *black box* was almost becoming main-stream in the 1970s. Unfortunately, or possibly not, there was a lull in the 1980s regarding research using AEPs. In addition, the limitations of single cell brain recordings

became evident. The emphasis on AEP technique and inadequate control over and interpretation of results, limited their usefulness. And the difficulty of measuring the coordinated activity of multiple neurons using single cell recordings limited our ability to understand neural processing mechanisms in the brain. There needed to be a consolidation of findings, clearer definition of what was being measured, and new techniques for studying brain activity.

Breakthroughs that changed everything followed the work of A. M. Cormack (1963, 1964) and G. N. Hounsfield (1973), who shared the 1979 Physiology or Medicine Nobel Prize for their work on x-ray computed tomography, and the high resolution brain imaging techniques initially developed by P. Mansfield (1977) and P. Lauterbur (1973), who shared the 2003 Nobel Prize in Physiology or Medicine. Their seminal work made positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) feasible, providing high resolution spatial map snapshots of brain activity associated with specific stimuli and specific thoughts.

These high resolution images of the brain were combined with event-related potentials (ERP), a refinement of AEPs that related temporal brain activity associated with the spatial maps generated by PET and fMRI (Luck, page 267, 2005). In addition, headway was made on localizing ERP sources in the brain by combining techniques, ERPs, PET, fMRI, MRI, and event-related magnetic fields (ERMF), a technique measuring the brain's magnetic activity that is not impeded by tissues of the head (Handy, 2005; Luck, 2005; Regan, 1989).

While these improvements in research technology radically changed our ability to investigate the brain mechanisms for processing information, attention, perception, emotion, and consciousness, the hardware did not tell what questions to ask or how to set up meaningful research strategies. To this end there has been a quieter revolution in the neurosciences, perception and cognitive psychology. F. Crick (1995), one of three recipients of the 1962 Nobel Prize in Physiology or Medicine for work on the three-dimensional molecular structure of DNA, made a call to scientifically study the mechanisms of consciousness. This was followed by F. Crick and C. Koch (1998) reviewing the possible neural mechanisms related to consciousness.

Research associated with binocular rivalry, ambiguous figures, and visual masking has been at the forefront of providing these experimental strategies. D. Alais and R. Blake (2005) and R. P. O'Shea (2003) provided an extensive review and bibliography, respectively, of the research on binocular rivalry and ambiguous figures and the techniques for studying how we process them. And B. G. Breitmeyer (2007) and B. G. Breitmeyer and H. Ogman (2006) have extensively reviewed their work and the work of others on visual masking. H. Ogman and B. G. Breitmeyer (2006) edited a book detailing the first half second of the "micrognesis and temporal dynamics of unconscious and conscious visual processes." C. M. M. De Weert, P. R. Snoeren, and A. Koning (2005) investigated the relationship between binocular rivalry and Gestalt formation and S. Han (2004) demonstrated a temporal relationship between Gestalt grouping and ERPs.

K. Nader, G. E. Schafe, and J. E. Le Doux (2000), E. F. Loftus (2003, 1997), C. B. Momou, K. Gamache, and K. Nader (2006), and Doyere et al., (2007) showed that memory is not a static thing, but can be changed with its regeneration/reconsolidation. Their work may even lend some credence to the efficacy of talk therapies and adds the future possibility of chemical interventions to erase traumatic experiences, as with traumatic brain injury (TBI). K. Arfanakis, V. M.

Haughton, and J. D. Careq (2002), E. D. Bigler (2005), and F. M. Kraus, et al. (2007) found that diffuse axonal injury (white matter) in the brain resulting from TBI, including concussive injury, can have chronic cognitive consequences.

This brief account provides the context and current relevancy of the research presented in this technical report, Effects of Form Perception and Meaning on the Visual Evoked Potential. The data were obtained between 1976 and 1979. During this period there was little work on ERPs related to ambiguous figures and meaningful trigrams. However, much related work has been done since, as witnessed by the following bibliography. It should be noted that this introduction is not a review of the literature and does not include all of the references listed below. The following, abbreviated bibliography is designed to provide current references, a start for individuals wishing to pursue this type of work.

The primary purpose of this research was to determine if differential visual evoked responses (VER; or visual evoked potential [VEP]) could be generated by different conscious percepts of the same ambiguous figure. In similar fashion, could changing the meaning of consonant-vowel-consonant trigrams by reversing the order of the consonants produce different VERs?

There were two main reasons for structuring the study in this way. First, to try to obtain noninvasive VERs that are related to perception and not simply stimulus-level processing (i.e., try to obtain indicators of higher order processing, what is going on in the *black box*). To do this required stimulus control. This was accomplished by looking at two interpretations of the same stimulus, in this case a reversible wedge and a reversible staircase, and to look at differences in meaning from word stimuli that had essentially the same retinal footprint. The second reason was to see if a tool might be developed that could monitor and evaluate the effectiveness of therapeutic interventions associated with problems like dyslexia, what was probably a higher order brain processing problem and certainly a perceptual problem.

In general, VER differences were found for the different interpretations of reversible figures. Any differences in VERs associated with differences in cvc trigrams was probably only at the level of meaningful versus nonsense. However, it may well be that the VER can readily pick up differences in affect resulting from differences in trigram meaning.

The noninvasive techniques used here, and particularly updated variations extended from the current literature, have the potential to detect, monitor and evaluate temporal aspects of perceptual, cognitive, language and emotional function that is affected by concussive brain injury resulting from sports, accidents, or war (including blast). When combined with fMRI, ERPs can provide information on both the brain's spatial and temporal processing.

In addition to dyslexia and TBI, these techniques may provide a simple means to assess, evaluate and monitor neural processing in degenerative brain diseases, detect long-term cognitive consequences of migraine, or monitor therapeutic interventions in the rehabilitation of traumatic stress disorders.

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9 July 2009

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EFFECTS OF FORM PERCEPTION AND MEANING

ON THE VISUAL EVOKED RESPONSE

A Dissertation
Presented to the
Faculty of the Department of Physiological Optics
University of Houston
College of Optometry

In Partial Fulfillment
of the Requirement for the Degree
Doctor of Philosophy

By
Melvyn Ernest Kalich
August, 1980

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Differential effects of simple geometrical forms of different angular subtense, trigrams with differently ordered letter elements, and different interpretations of reversible figures on the visual evoked response were intensively studied with three adult human subjects. Stimuli were all black line figures subtending less than 2^{o}, presented in random order with a random interstimulus interval against a white, square, 10^{o} background. Visual evoked responses were obtained from six active electrode sites (O_1, O_2, P_3, P_4, F_7, F_8) with a common linked ear reference.

An algebraic description of each visual evoked response was provided by Fourier analysis. Visual evoked responses were digitally filtered by setting all frequency and phase components above 29 Hz to zero. All stimuli were replicated allowing the determination of error distributions for 29 frequency components. Differences in visual evoked response wave forms generated by different stimuli were defined when differences between one or more frequency components were greater than differences resulting from replications of both stimuli. Results were then placed in binary arrays for comparisons across subjects.

Results show that differences in the interpretation of a reversible figure produce distinctly different VERs. This was interpreted as resulting from perceptual, rather than sensory processes. VER differences were also found resulting from differences in geometrical figure form and angular subtense. The geometrical figure VER differences were all attributed to sensory processes. VERs obtained from

all trigrams with different letter orders were distinctly different. However, only composite VER comparisons indicated a systematic difference between meaningful and nonsense trigrams. This was interpreted to mean that the VER does not resolve differences in meaning between individual trigrams but VERs may distinguish between meaningful and nonsense trigram classes. Possible sources of differences in results obtained in this and other studies were discussed. Additional studies based on these results were suggested.

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INTRODUCTION

A. Purpose of the Study

The relationship between visual evoked responses (VERs) recorded from the scalp of human subjects and the perception and meaning of specific visual forms has been elusive. John, Herrington and Sutton (1967) demonstrated distinctly different, within subject VERs associated with simple geometric forms (□ , ◇ , ○). However, lack of quantification and problems with figure choice (to be discussed further below) leave considerable doubt as to whether or not they actually isolated correlates of the unique representation of their figures. Herrington and Schneidau (1968) investigated the effects of instructional set on VERs using the same figures and presentation procedures as John, Herrington and Sutton. Observers were asked to imagine specific figures when the same and different figures were presented. They found a close relationship between figures "imagined" and VERs for <u>some</u> subjects, regardless of figure presented. Weinberg, Walter and Crow (1970) and Weinberg, Walter, Cooper and Aldridge (1974) extensively investigated emitted potentials (evoked potentials from randomly omitted, but expected stimuli). Using a template matching procedure they demonstrated considerable variance in emitted potential onset, bringing into question use of this technique combined with simple averaging as a means of investigating higher order processes. Difficulty Herrington and Schneidau had in obtaining reliable results from some subjects may have been due to the inability of instructional set to establish a reliable, time locked expectancy response to presented stimuli.

Garcia Austt, Buno and Vanzulli (1971) used instructional set to bias subjects' interpretation of a Necker Cube or Peter-Paul goblet. Their results are very difficult to interpret because relatively few responses were averaged and few subjects were used. It was reported that distinctions between VERs resulting from different instructional sets sometimes disappeared after many stimulus presentations. No quantification of their data was attempted. Johnston and Chesney (1974) attempted to obtain different VERs from an ambiguous figure embedded in defining temporal contexts. Subjects vocalized their interpretation of the figure in a reaction-time paradigm leading Galbraith and Gliddon (1975) to demonstrate a high probability that their results were due to vocalization artifact.

Problems have existed at all levels in these studies: (1) choice of stimuli; (2) specification of stimulus parameters; (3) experimental procedures; and (4) quantification of data. As a consequence it has not been clearly demonstrated that the VER can differentially reflect cortical representation of simple, whole geometric forms. This present study is an effort to extend this earlier work to relate form perception and meaning to the VER and to overcome some of the problems that have been encountered.

B. <u>Historical Review</u>

Beginning with Richard Caton in 1875 (Lindsley, 1969) and Hans Berger (P. Gloor, 1971) there has been an interest in the relationship between slow potentials recorded from the scalp and brain surface and "mental processes." Caton noticed that this activity was influenced by a variety of things including sensory stimulation. There is some evidence that his work anticipated electroencephalography (EEG), evoked potentials (EPs), and contingent negative variation (CNV). Beginning in 1924 Berger followed up on Caton's work first using a reflected light amplification galvanometer and later a coil galvonometer. He published his first paper on the "elektrekephalogram" in 1929 while at the Psychiatric Clinic at Jena. Berger's work received little recognition until E. D. Adrian replicated his work and gave it considerable publicity. The years that followed showed an accelerated, increasing interest in EEG, slowed only by the Depression and WW II (P. Gloor, 1969; E. D. Adrian, 1971; P. Gloor, 1971; and W. Cobb, 1971).

Before the 1940's unambiguous evoked potentials recorded at the scalp rarely showed through the ongoing EEG. Small EPs (2-20 μV) and the larger EEG (10-50 μV) combined with other, often larger physiological potentials producing a poor signal-to-noise ratio. The development of amplifiers and filtering techniques did not help, as frequency components of the "noise" significantly overlapped with those of the EP.

G. D. Dawson (1947, 1950, 1951, and 1954) first began to attack this problem by developing time-locking recording techniques, allowing superimposition and averaging to be used. These techniques, first suggested by Laplace and Galton, had long been used in physics (isolation of lunar tidal forces on the atmosphere) and engineering (radar) to clarify time relations between events and enhance signal-to-noise ratio.

Continued improvement of equipment was made by investigators including Calvet and Sherrer (Bergamini and Bergamasco, 1967), Buller and Styles (1959), Barlow (1957), and Cooper and Warren (1961). However, it was not until Clark and coworkers at the Massachusetts Institute of Technology (1961) developed the Average Response Computer (ARC) that digital computers were applied to the problem. The principles of the ARC were applied in constructing other digital averaging computers that were soon marketed and in wide use. Thus, the floodgates for EP research were opened.

John and Killam (1960), John (1961) and John, Ruchkin and Villegas (1963) were among the first to look at meaning and its relation to the VER. Using clicks of different frequency in a discrimination conditioning and generalization paradigm they found that there was congruence of distinctive VER forms, each associated with a particular stimulus and behavioral outcome, in a wide variety of brain areas that was highly predictive of a cat's behavior.

Recording from human subjects, Chapman and Bragdon (1964) associated an increased amplitude in early VER components with the

task relevance of number stimuli. Walter (1965) interpreted an increase in CNV amplitude and amplitude of a late positive VER component with attitude set of subjects toward both stimuli and experimental tasks. Lipshitz (1966) interpreted changes in early (75 to 150 ms) and late (250 to 400 ms) components of the VER to subjects' positive and negative associations with complex stimuli.

John, Herrington and Sutton (1967) did a particularly interesting study on the relationship between "form perception" and the VER. Their findings indicated that different geometric shapes produced reliable, distinctive VER forms. Such distinctive VERs were also produced by geometrical figure names. That these distinctive VER forms were relatively independent of stimulus size (4 in^2 vs. 64 in^2) was central in their argument that the VERs obtained were correlates of "perceptual rather than sensory processes."

In 1967 Sutton, Tueting, Zubin and John, using an information delivery paradigm, found that a positive component peaking at approximately 300 ms (P300) was associated with uncertainty resolution.* At about this same time Begleiter, Gross and Kissin (1967) found similar, significant amplitude differences in four VER components based on association with different affective stimuli. Semantic loading of normally neutral visual stimuli was accomplished without subject awareness in a balanced design. Greatest mean amplitude

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*Although this is not the first study in which the P300 component was found, it is representative. The number of such investigations to date exceeds 200, too many to review here in even the most cursory fashion.

for all four components was from the VER associated with the neutral stimulus, followed by that associated with the positive stimulus, followed in turn by that associated with the negative stimulus. Begleiter and Platz (1969a) confirmed their earlier results in another study showing that the effect was subject to acquisition, extincition, and reacquisition. In a subsequent study investigating taboo words vs. neutral words and a blank field Begleiter and Platz (1969b) found increased amplitudes for two VER components associated with the taboo words.

In a very unusual study that seems fairly well controlled, Herrington and Schneidau (1968) presented blank and 64 in^2 circle and square stimuli in the same fashion as John, et al. (1967). Using a Latin square design, subjects were asked to imagine or visualize a square when a circle was presented, a circle when a square was presented, a circle (or square) when a blank was presented, or a square (or circle) when a square (or circle) was presented. They obtained different VER shapes for the square-imagined square and circle-imagined circle condition that were replicated. Based on results shown from three of their subjects they obtained convincingly similar VERs from the square (or circle)-imagined circle (or square) and the circle (or square)-imagined circle (or square) conditions. Although VERs resulting from the blank-imagined circle (or square) were unlike the VERs when the figures were presented, replicable, differential VERs were obtained from the two conditions. Training was given to relax subjects and to avoid vocalizations or

tensing of facial muscles. Electro-oculograms (EOGs) were recorded to evaluate the effect of eye movements.

A less dramatic but nonetheless interesting study on differential processing of visual information in the two cerebral hemispheres was done by Buchsbaum and Fedio (1969). They presented computer generated dot patters on a LINC computer screen. In this fashion they could generate long sequences of meaningful trigrams, geometrical shapes, and trigrams based on a meaningless computer alphabet. VERs were obtained from each stimulus class; no stimulus within a class being repeated during a recording session. They found that VER differences from word and nonword stimuli were more different when from the left than when from the right hemisphere. Word stimuli had shorter latencies than figures.

Weinberg, Walter and Crow (1970) reported a study based on VERs obtained from chronically indwelling electrodes in human patients with severe intractable anxiety. The electrodes were placed in the gray matter of the orbito-frontal and cingulate cortex and on the surface of the superior frontal cortex. Evoked responses were obtained from expected, but randomly omitted flashes, clicks, or mild electric shocks to the finger (emitted potentials), as well as from presented stimuli (EPs). The subjects were asked to predict whether or not a stimulus would be presented by a preceding lever press during experimental trials. Control trials were run without subjects making guesses. Emitted potentials were clearly produced and resembled EPs, including a P300 potential

during expectancy runs. Emitted potentials occasionally had shorter latencies. Weinberg, et al. interpreted the emitted potential as being correlated with "memory processes corresponding to perception of real events."

Using a template pattern recognition technique based on cross-correlational statistics in a followup study, Weinberg, Walter, Cooper and Aldridge (1974) demonstrated that the onset of emitted potentials may vary by 30 ms from a cueing stimulus. This would make normal averaging procedures difficult. Clearly such onset variability would reduce VER amplitude, distort the waveform and blur high frequency components.

In a paper reviewing their work on EPs and central processing of visual information, Garcia Austt, Buno and Vanqulli (1971) showed VERs from a number of stimulus conditions. One of these was a clear secondary occipital VER beginning 100-150 ms after a high intensity, 8 ms flash when and only when adult subjects indicated seeing an after-image. The secondary VER was similar in shape, components and amplitude with the first 100 ms of the record. Newborn VERs showed the same results.

A second part of their report gave results based on instructed interpretation of reversible figures (Rubin's Peter-Paul goblet and a Necker cube). Differential, replicable VERs were obtained, although it is not clear whether it was a result of instruction to imagine one or the other form as in Herrington and Schneidau's (1968) study or a consequence of actual perceived differences in figure form.

A third part of the Garcia Austt, et al. (1971) paper dealt with the influence of experimental program on the VER. Effects obtained in the early part of a record may disappear after prolonged exposure to a repeated stimulus, or effects obtained in VERs during the first of a series of repeated sessions may be missing from later sessions.

Symmes and Eisengart (1971) did a study with children purporting to show a correlation between subject interest in and perceptual integration of complex visual stimuli (cartoons and familiar household objects) and a slow negative vertex potential peaking at 500 ms. Their "VERs" showed a "significant" lack of familiar VER features.

Shelburne (1972) investigated the effect of word and nonsense syllables on the VER in an information delivery paradigm. Letters of a three-letter trigram were sequentially presented and the subject asked to make a following motor response indicating whether or not the trigram formed a word. The first two letters were the same in either case, making the last letter the key to the meaning of the trigram.

No consistent differences were found between meaningful and nonsense trigrams nor between left and right hemispheres. The key letter did consistently produce a VER with a late positive component (450-550 ms) with greater amplitude.

Begleiter, Porjesz, Yerre and Kissin (1973) found that a "medium" intensity flash preceded by one of two tones that had previously indicated a coming bright or dim flash produced different

vertex VER amplitudes based on subject expectancy. Occipital VERs showed no differences.

In a similar study, Begleiter and Porjesz (1975a) required subjects to make a forced-choice as to whether a single "moderate" intensity flash was bright or dim. This stimulus was presented in a random fashion within a context of noticeably brighter and dimmer flashes. They stated that they found significant differences in $P_1 - N_1$ (100 - 140 ms) and $N_1 - P_2$ (140 - 200 ms) components of the VER based on a "bright" or "dim" decision. Donchin (1975) criticized their study based on their shown representative data. He could not see differences in superimposed VERs that were described. In response, Begleiter and Porjesz (1975b) essentially stated that he didn't look hard enough.

A particularly interesting study was reported by Johnston and Chesney (1974). An ambiguous visual stimulus, 13, was imbedded in a temporal number or letter context. Midline frontal, temporal, and occipital VERs resulting from the same stimulus, but different contexts, were subjected to a factor analysis. It showed differential loading for a factor beginning at 160 ms and, for two subjects, one between 100 and 140 ms. No differences were obtained from occipital VERs.

Their study was severely criticized by Galbraith and Gliddon (1975) on the basis that subjects were required to vocalize the stimulus using a reaction-time procedure. They found that large potentials preceded such vocalizations and were reliably and differen-

tially related to the phoneme to be pronounced. Such vocalization potentials overlapped with the significant components found in the ambiguous figure VERs.

Using sequentially flashed words to form a sentence, Friedman, Simson, Ritter and Rapin (1975b) investigated the effects of information delivery on the VER. The meaning of the sentence was conveyed in one of two locations, the second or last word of the sentence. They found mixed results regarding hemispheric assymetries, concluding that there were none. The last word in the sentence invariably produced a higher amplitude P300 which they suggested might be related to "semantic closure." Information delivery did not significantly affect P300 amplitude, but did consistently produce longer latencies. All word stimuli produced P300 waves, confirming the author's speculation that it is related to a system that is "engaged when language stimuli are presented and the subject has a task."

Courchesne (1977) investigated differences between adults (25-35 years) and children (6-8 years) regarding VER responses to rarely presented visual stimuli associated with or unassociated with a counting task. Although no substantial differences in scalp distribution or amplitude of P300 waves were found in the two groups, consistently longer latencies were found for children, suggesting "differences in speed rather than mode of processing." Adults did, however, show variations in scalp distribution of the P300 component that seemed related to ease of stimulus recognition and degree of stimulus novelty.

Chapman, McCrary and Chapman (1978) found a positive VER component recorded from CPz and peaking at 250 ms that seemed related to short term memory storage (icon). Prediction of recall on task relevant and task irrelevant stimuli was directly related to the amplitude of the component.

Several studies relating word meaning to auditory evoked potentials have some bearing on this study. Teyler, Roemer, Harrison and Thompson (1973), Roemer and Teyler (1977), Brown, Marsh and Smith (1973), Brown, Marsh and Smith (1976), and Marsh and Brown (1977) have all found hemispheric differences in VERs from ambiguous words defined by different contexts. Differences resulting from homophones in different defining temporal contexts also produced different VERs over both Broca's and Wernicke's areas.

It seems, based on a general overview of the above studies, that late components of the VER (200-600 ms) vary with both exogenous and endogenous processes. A large number of experimental strategies have been used to investigate these VER components and a large number of names attached to processes presumably related to their generation. With the exception of two studies, one by John, Herrington and Sutton (1967), and one by Garcia Austt, Buno and Vanzulli (1971), there has been little work relating visual form perception and related changes in meaning to the VER. Because these two studies relate directly to the problem I am investigating here, I will review them in some depth.

C. Detailed Review of Two Articles: John, Herrington and Sutton, 1967; Garcia Austt, Buno and Vanzulli, 1971

John, Herrington and Sutton (1967) investigated the relationship between the "waveshape of the evoked potential and the geometric form of visual stimuli." This study was discussed and additional data presented by John (1967a) and Thatcher and John (1977). Recordings were obtained from an active electrode placed 3 cm above the inion referred to the right earlobe. Amplifier time constant settings were 0.3 with an output range of $\pm$ 3V.

Four comparisons were made in their study: "A blank visual field versus a field containing a geometrical shape, one shape versus a different shape of equal area (squares, diamonds, circles), two identical shapes of different area, and two words, 'square' and 'circle' printed with capital letters equated for area." Figure areas for which VERs were obtained and shown were: squares (412.8 cm^2 and 25.8 cm^2), diamonds (412.8 cm^2, 103.2 cm^2, and 25.8 cm^2), and circles (412.8 cm^2, 103.2 cm^2, and 25.8 cm^2). The area or angular subtense of the words "square" and "circle" were not provided. The blank field was presumably a wall without figures mounted.

Subjects sat in a contoured chair facing a wall 150 cm away. The room was darkened. With the exception of the blank field condition, stimuli were "...presented either as black metal plaques or as black figures drawn on sheets of white cardboard mounted on a white wall..." Silent, square wave flashes of 20 ms duration were produced by two Iconix flash units placed behind the subject and

facing the rear wall. "Intensity" at the stimulus plane was 0.585 lm/m^2. Actually, these are units of illuminance, not intensity. Flash rate was 2 per s. Subjects were instructed "only to observe what was before them."

Control studies were done in a few cases to assess eye movements, pupillary changes and possible vocalization effects. Oculograms showed little eye movement and their averages during different stimulus presentations were "essentially the same." Use of homatropine and an artificial pupil prevented pupillary and accomodative changes. "Differential feedback from the vocal musculature was prevented by requiring the subject to count the stimuli in each sequence." The authors stated that these precautions did not affect their results, although no confirming data was presented.

One hundred seventy-four experiments were conducted with 20 subjects using a 2 x 2 Latin-square design for each experiment (two VER replications for each of two different stimuli). "Four averaged evoked responses were computed from blocks of 25 or 50 presentations of each stimulus of a particular pair." This design provided controls for habituation, fatigue and recency.

Of the twenty subjects, twelve gave consistent and replicable wave-shape response patterns with seven of the twelve giving consistent response patterns "when tested repeatedly with all four sets of stimuli over periods up to 4 months." Of the eight subjects that did not give replicable wave-shapes, seven did give reproducible, differential responses to at least one pair of figures. Six of these

seven showed high response variablilty within single sessions. Two of the eight subjects showed essentially similar wave-shapes to most stimuli. "In a number of instances reproducible differences between replicated averages based on 25 or 50 stimulus presentations diminished or disappeared when the same size was increased to 100 or 200, or as the experimental session continued," suggesting habituation.

The results in this study were based on visual inspection of VER wave-shapes from the twelve subjects showing reliable results. However, some effort was also made to quantify results by computing a descriptor λ ("root-mean-square differences between two sets of waveforms evoked by dissimilar stimuli to the root-mean-square difference between two sets of replicated waveforms evoked by similar stimuli"). When λ exceeds unity, the difference between dissimilar stimuli is greater than the difference between replicated or similar stimuli. Probability statements could not be computed because the distribution of λ is unknown. Results obtained by inspection were confirmed by this analysis.

"The results obtained from 60 percent of our subjects support the following conclusions: (i) the response evoked by a blank visual field is altered by the presence of a geometric form in the field; (ii) different shapes of equal area elicit different responses; (iii) similar shapes of different area elicit similar responses; and (iv) different words printed with letters equated for area elicit different responses."

Inspection of their results would also confirm two additional conclusions: (1) waveform was consistent within, but not between subjects; and (2) differences between stimuli tended to show up in components occurring later than 150 ms.

Although John and coworkers showed reliable differences in VERs obtained from different geometrical forms for 60 percent of their subjects, these differences were small. Even though not stated, their VERs appear to have been drawings from as opposed to plots of original data. There is a distinct lack of higher frequency activity in records shown that would be expected from some subjects, at given filter settings, from averages of 25 or 50 stimulus presentations. No voltage scale is provided, so it is difficult to determine what voltage-to-time ratios are shown, providing another possible explanation for the smoothness of their curves. Whatever the case, independent assessment of error resulting from replications is difficult. Replication of these results in a different laboratory would be in order.

A second question arises regarding choice of stimuli. Rotation of a square to produce a diamond does provide area and reflection controls, but it introduces the possiblity that VER differences between a square and a diamond resulted from oblique effects and not from a higher order perceptual process involving comparison of forms. This may particularly be true with the low "intensity" flashes used [Campbell, Kulikowski and Levinson (1966); Campbell and Maffei (1970); Halliday and Michael (1970); Michael and Halliday (1971); and Maffei

(1977); Smith and Jeffreys (1978).

Differences in VERs resulting from squares or diamonds and circles may be the result of differences in the ensemble activity in cortical areas 17, 18, and 19 associated with straight lines of different length and orientation versus curves. It may very well be that these VER differences are a result of straight lines versus a curve and not a square versus a circle.

A portion of the paper by Garcia Austt, Buno and Vanzulli (1971) was on different VERs obtained from different instructional sets associated with reversible figures. Records were obtained from active electrodes positioned at Oz and Cz (10/20 electrode placement system) and referenced to the right mastoid. VERs were based on sums of 17 (Necker Cube) and 50 epochs (Robin's Peter-Paul goblet), each of 500 ms duration. Amplifiers of unspecified type were used with filter "time constant settings of 0.65 or 0.80." It was not clear if these settings were for high or low frequency filters or both. Data was recorded on magnetic tape.

Stimuli were on cards of unspecified size placed 40 cm from the subject's eyes on a black background. Flashes were produced by a Grass photostimulator set 150 cm from the stimulus card. Relative intensity settings of 1 or 2 were used. Whether or not the experimental room was darkened was not specified. Interflash interval was randomized. Each VER obtained from Rubin's figure was replicated.

Fixation was maintained by a light fixation dot during darkness. Horizontal eye movements were monitored by EOG and "none occurred."

Instructional set for the two stimuli apparently differed. The subject was asked to see "goblet" or "faces" for Rubin's figure. It is unclear whether or not a verbal response was given after each presentation. The subjects observing the Necker cube were instructed to say "up," "down," or "doubtful" after each stimulus presentation.

Analysis was by visual inspection only. For the one subject, differences in interpretation of Rubin's figure showed in the amplitude of an early negative component (approximately 90 ms) of the occipital VER. No obvious differences occurred in vertex VERs as a consequence of interpretation differences.

Only occipital VERs were obtained from the Necker cube. Data from two subjects was shown. The first subject showed a "clear second negative wave" for the "down" interpretation. The "up" and "doubtful" VERs were most similar, with both showing a large positive wave peaking near 500 ms. VERs from the second subject showed a smaller amplitude for the first negative (approximately 130 ms) and positive (approximately 160 ms) components for "up." The "down" and "doubtful" VERs were considered most similar.

The data presented by Garcia Austt and coworkers showed differences between VERs that were small, and with respect to unreplicated Necker cube data, on only 17 epochs. There was a real possiblity of vocalization artifact (Galbraith and Gliddon, 1975). Stimulus parameters and recording conditions were poorly specified. Although the authors state that there were no horizontal eye movements, a blink artifact shown superimposed over a VER and described as clearly

unrelated makes me question this statement. That differences showed in such early components of their records suggests the possiblity that differential experimental factors may have influenced their results, not figure interpretation.

Deficiencies in their experiment aside, there is an additional concern. I attempted to replicate their results with 4 subjects and a number of versions of Rubin's figure and Necker cubes. A description of the procedures follows in the methods section of this paper. VERs from these figures could not be obtained due to an inability of all subjects to get a reliable distincition between interpretations, even when longer exposures to figures did allow clear, reliable distinctions to be made. In order to obtain VERs from reversible figures with short presentations, other stimuli had to be used; a reversible wedge and a reversible staircase. Both of these figures did produce sufficiently reliable results.

As a consequence of my own experiences, I wonder how much effect instructional set may have had on the Garcia Austt, et al. experiment. If Herrington and Schneidau's (1968) results are an indication, considerable.

There are obvious advantages in using reversible figures in experiments relating form perception and meaning to the VER. The above criticisms have in no way changed my views regarding this.

METHODS

A. Subjects

One female and two male human subjects between the ages of 27 and 36 years participated in this study. Two showed corrected 20/20 acuity or better during a preliminary eye examination. One required no correction. None of the subjects showed binocular problems, problems in fusion, or problems in accommodation. All subjects showed a normal fundus. No subject had a history of eye disease.

The subjects were all highly motivated and were trained observers in VER experiments before experimental data was obtained. All had a minimum of 20 hours in preliminary experience, which included training in relaxation while maintaining a steady vigilance and the development of a routine observation procedure. Feedback training was used when necessary to bring about subject control over blinking, muscle tensing, eye movements, and accommodative and fixation changes during stimulus presentation. Feedback training consisted of the experimenter's description of problems and, when necessary, subject observation of ongoing EEG on an oscilloscope screen. The object of this procedure was to minimize VER artifacts in later experimental runs. Training sessions were also used to adapt subjects to the experimental environment and to get past initial habituation effects in the VER.

Subjects were always informed about experimental particulars, although the overall plan and objectives of the experiment were not discussed in detail. Discussion of expected outcomes was avoided.

Presentation and subject identification of stimuli preceded every session. An experimenter inquiry and subject's description of responses followed every session.

Sessions lasted a minimum of two hours and a maximum of three hours (including one hour preparation). Five to ten minute breaks every 45 minutes or so were routinely given without removing the subject from the apparatus.

Data was acquired over a period beginning July, 1977, and ending October, 1978. As a consequence, sessions were not at regular intervals, but averaged once per week with very occasional two to three week periods during which there were no runs. For purposes of subject convenience, sessions occurred during all periods of the day. However, the vast majority of sessions for a particular subject occurred during the same period of the day.

Experimental sessions were scheduled days or weeks in advance. As a consequence, sessions occasionally had to be cancelled due to illness or a subject being on medication. Several times data collection during a session was stopped. This was due to equipment malfunction or to a subject being unable to concentrate on the task, as indicated by a very high rejection rate of EEG records due to artifacts. In all such cases, data from that session was excluded from the data analysis.

B. Apparatus*

Data was recorded using six Grass model P511 AC preamplifiers with HIP511 high impedance probes (Figures 1, 2, and 9). Each set of three amplifiers had its own external Grass RPS107 regulated power supply. Amplification was set at 10,000 X. The amplifier band pass was slightly less than 1 Hz to slightly greater than 70 Hz without amplitude attenuation and 0.1 Hz to 300 Hz with 50% attenuation. Amplifier calibrations, using the internal calibration pulse and DC offset adjustment, were done approximately once per week throughout the research period. This proved to be often enough for properly functioning amplifiers. However, amplifier malfunctions did occur on nine occasions. Each time this occurred, the malfunctioning amplifier was replaced by a new unit and all the amplifiers recalibrated.** Data collected from the time of the previous calibration was rejected and rerun at a later time.***

Data was averaged and stored on a Nicolet MED-80 computer with floppy disc storage and Texas Instrument Silent-700 terminal. Data was plotted using a Hewlett Packard Model 7004B X-Y plotter with Model 17178A attenuator. See Figures 1 and 3 for additional detail.

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*For further information regarding the apparatus see Figures 1 - 9.

**The malfunctioning amplifiers were returned to the manufacturer. They confirmed the malfunction in every case.

***An initial session was repeated toward the end of the first part of data acquisition; a replication session at the end of the replication part of data acquisition.

Figure 1. Basic instrumentation used in this study.

O_1, O_2, P_3, P_4, F_7, F_8	Active electrodes
HP	Grass HIP511 high impedence probes
G_2	Reference electrode connections
Gr	Ground connections
A	Grass Model P511 AC preamplifiers
Oc	Computer oscilloscope
C	Nicolet Med-80 computer
Om	EEG monitoring dual beam oscilloscope
LC	Logic control (for stimulus selection and interstimulus interval)
P	Random access projector
Pl	Hewlett-Packard Model 7004B X-Y plotter
T	Texas Instruments Silent 700 computer terminal
M_1 & M_2	First surface mirrors
PS	Kodak Black Glass back projection screen
S	Subject response switches

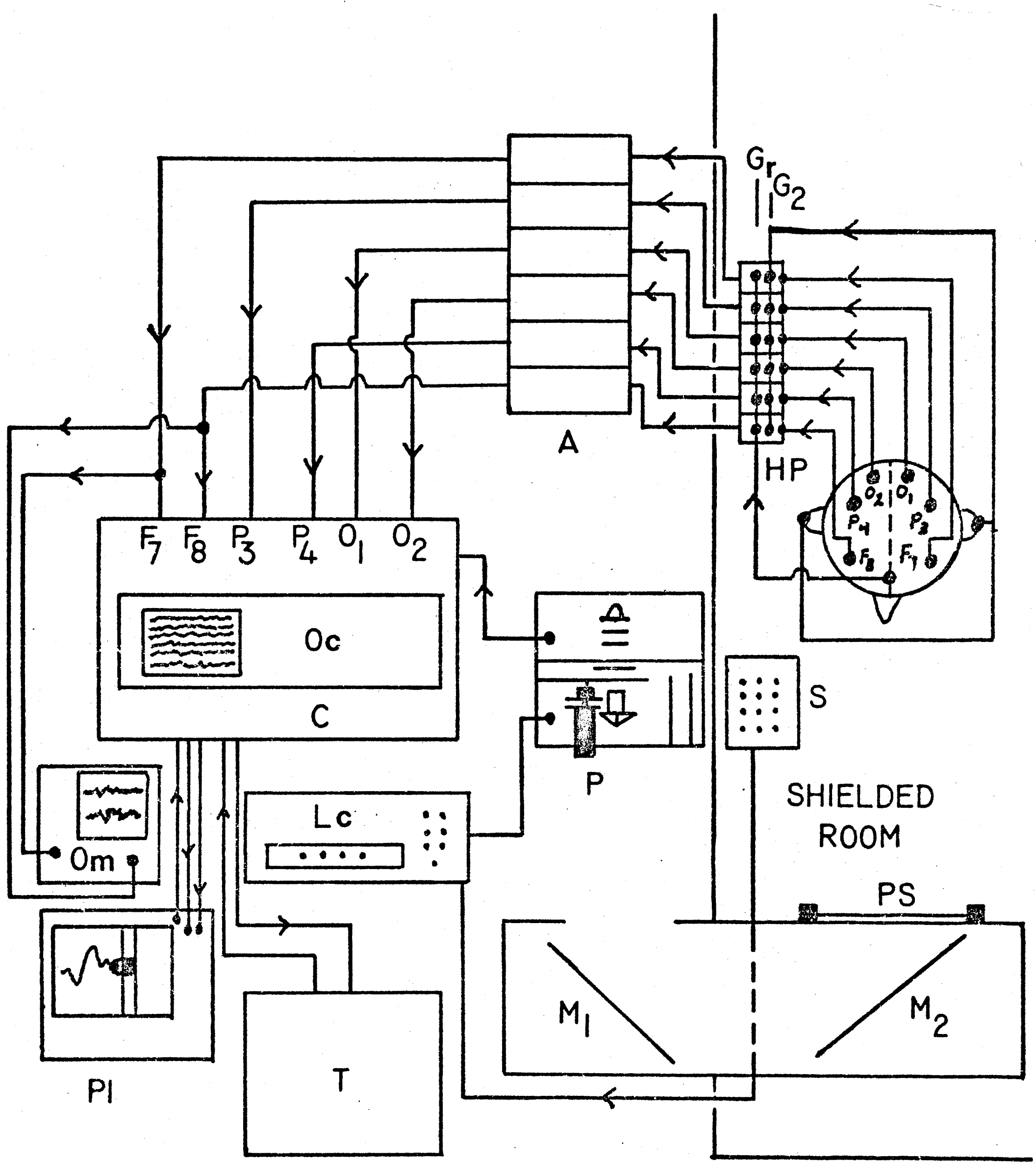

A
HP
G1
G2
O2
O1
P4
P3
F8
F7
F7
F8
P3
P4
O1
O2
Oc
C
P
S
SHIELDED
ROOM
Lc
Om
PS
M1
M2
Pl
T

Figure 2. Arrangement of basic instrumentation.

P	Random access projector
M	Mirror housing
Lc	Logic control (for stimulus selection and interstimulus interval)
Vc	Variable transformer for source voltage control
I	Intercom
T	Texas Instruments Silent 700 computer terminal
C	Nicolet Med-80 computer central processor
Om	EEG monitoring dual beam oscilloscope
A	Grass Model P511 AC preamplifier

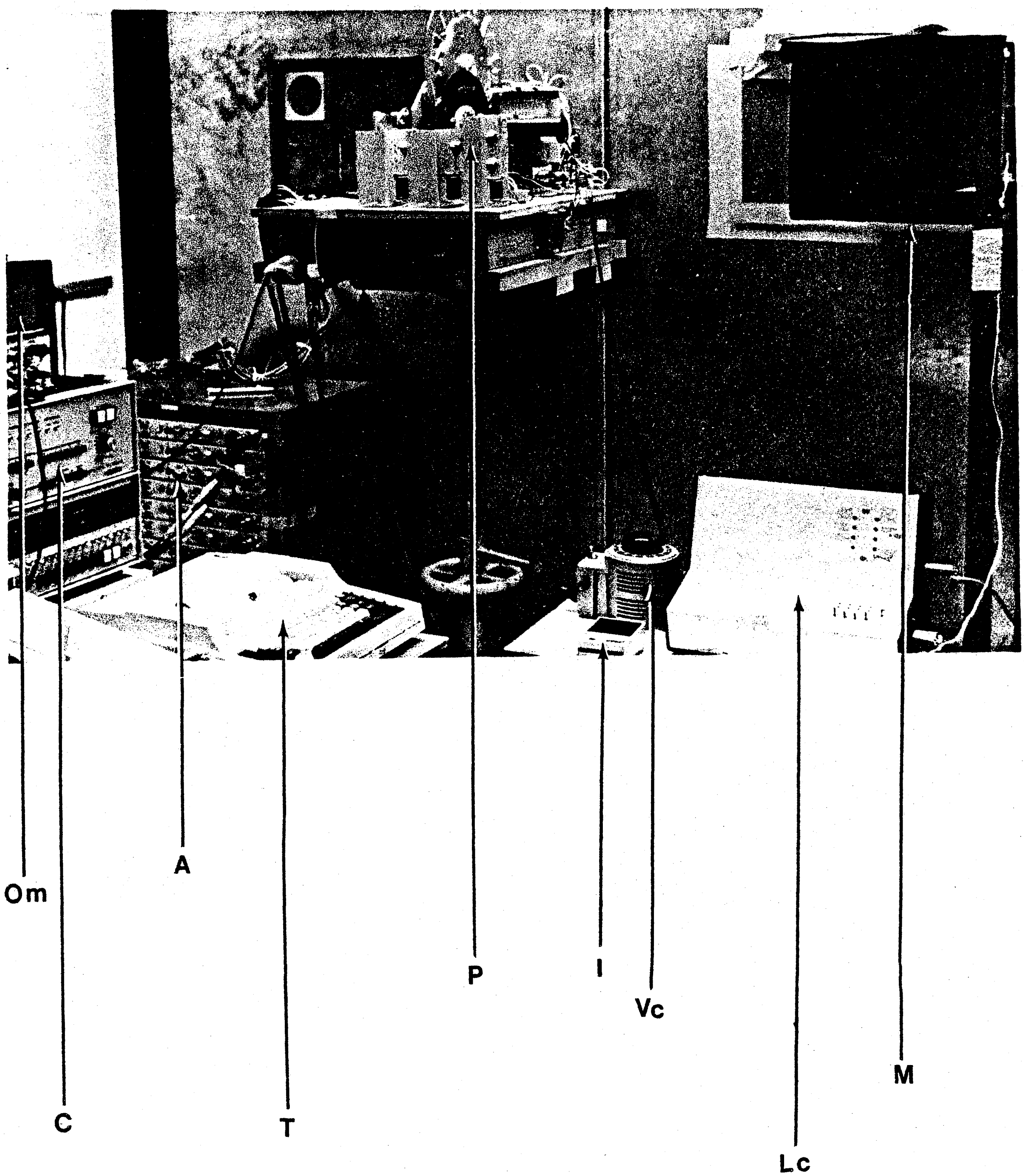
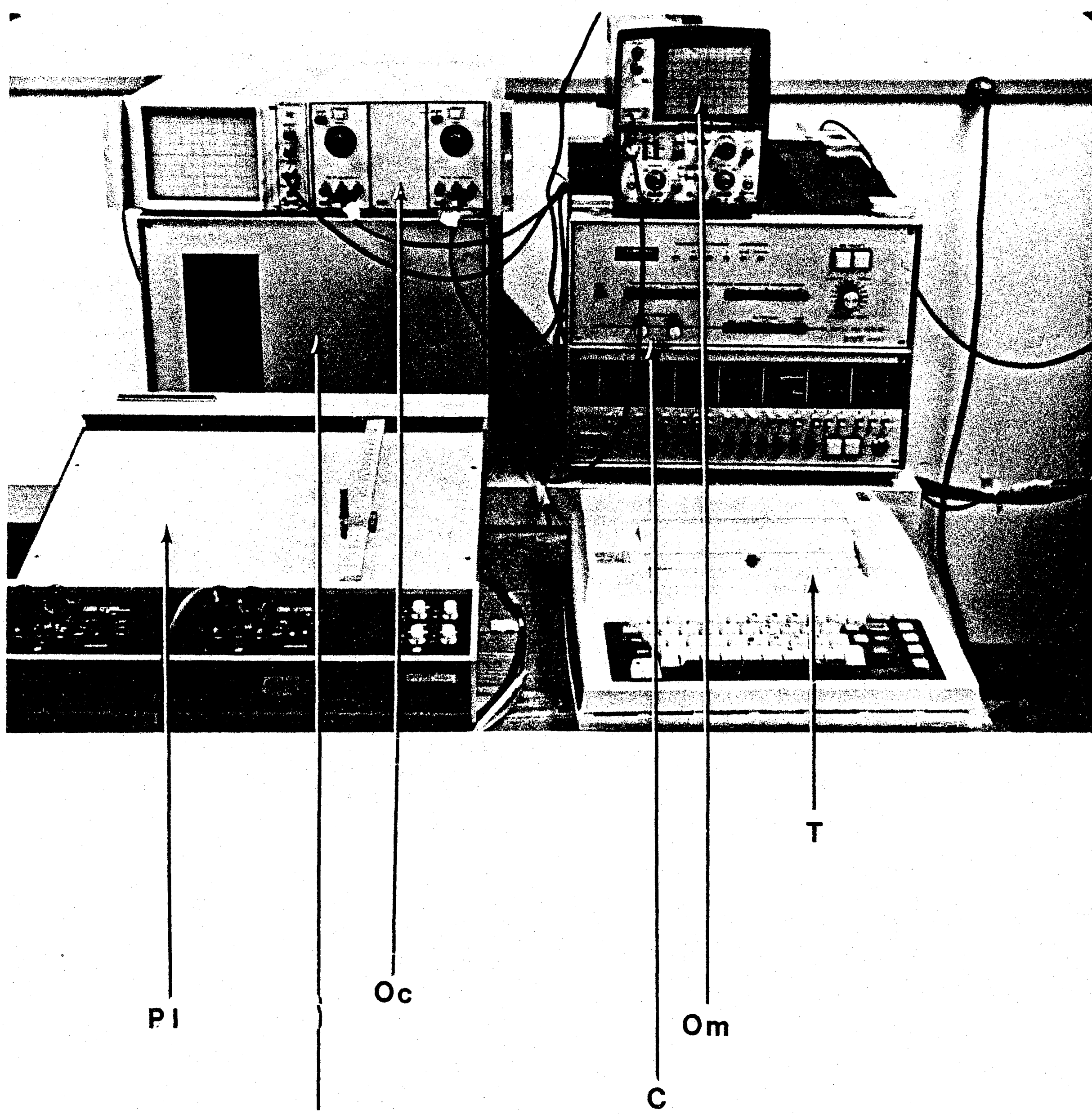

Om
C
A
T
P
I
Vc
Lc
M

Figure 3. Data processing instrumentation.

Oc	Computer oscilloscope
D	Floppy disc drive
Om	EEG monitoring dual beam oscilloscope
C	Nicolet Med-80 computer central processor
T	Texas Instruments Silent 700 computer terminal
Pl	Hewlett-Packard Model 7004B X-Y plotter


T
Oc
Pl
Om
C
D

Electrode impedances were obtained before and after sessions using a Grass Model EZM electrode impedance meter. Rarely were impedances recorded above 6K Ohms, and never above 10K Ohms. Most records were obtained with impedances well below these figures. Impedances measured after each session were invariably equal to or less than at the beginning.

Stimuli were presented in random order with a random interstimulus interval, varying between 9 and 22 seconds. Computer trigger, stimulus slide search, onset of an adapting field, and stimulus presentation were controlled by hard wired logic. Stimulus selection was controlled by the experimenter using 4 switches connected to a control panel (Figures 1 and 2). The slide sequence was predetermined by a computer generated table of randomly ordered digits, each corresponding to a particular stimulus. A different sequence was obtained by changing the program seed value.

Stimulus and background were presented using a specially designed random access projector (Figures 4 through 7). The optics were essentially the same as for a Kodak 35 mm Carousel projector with a 300 Watt ELH halogen source using a double-wound coil and parabolic reflector (Figures 6 and 7). A 2.8, 3" f.l., short throw Kodak lens with film plane correction was used to focus slide images (Figure 7). The lens mount is shown in Figures 4 and 7.

Three additions to the above optics were made in this system. Each slide was divided into two fields that were cross polarized (Figure 7). Between the plane of the polarizers and the focusing

Figure 4. Random access projector (front view).

SW	Slide wheel--rotated by a stepper motor (not shown) under control of hard wired logic (not shown)
SPD	Slide position detector using 4 infra-red emitting diodes and phototransistors
SMD	Stepper motor driver
PLM	Mount for 2.8, 3" f.l. short throw Kodak projector lens (not shown)
Mo	Continuously running AC motor--driving electronic clutch (not shown) to rotate polaroid analyzer disc (RPA)
PrM	Base-to-base prism mount with prisms--shown separated from projector lens
RPA	Rotating polaroid analyzer--rotated when electronic clutch (not shown) engaged and braked when electronic clutch disengaged.

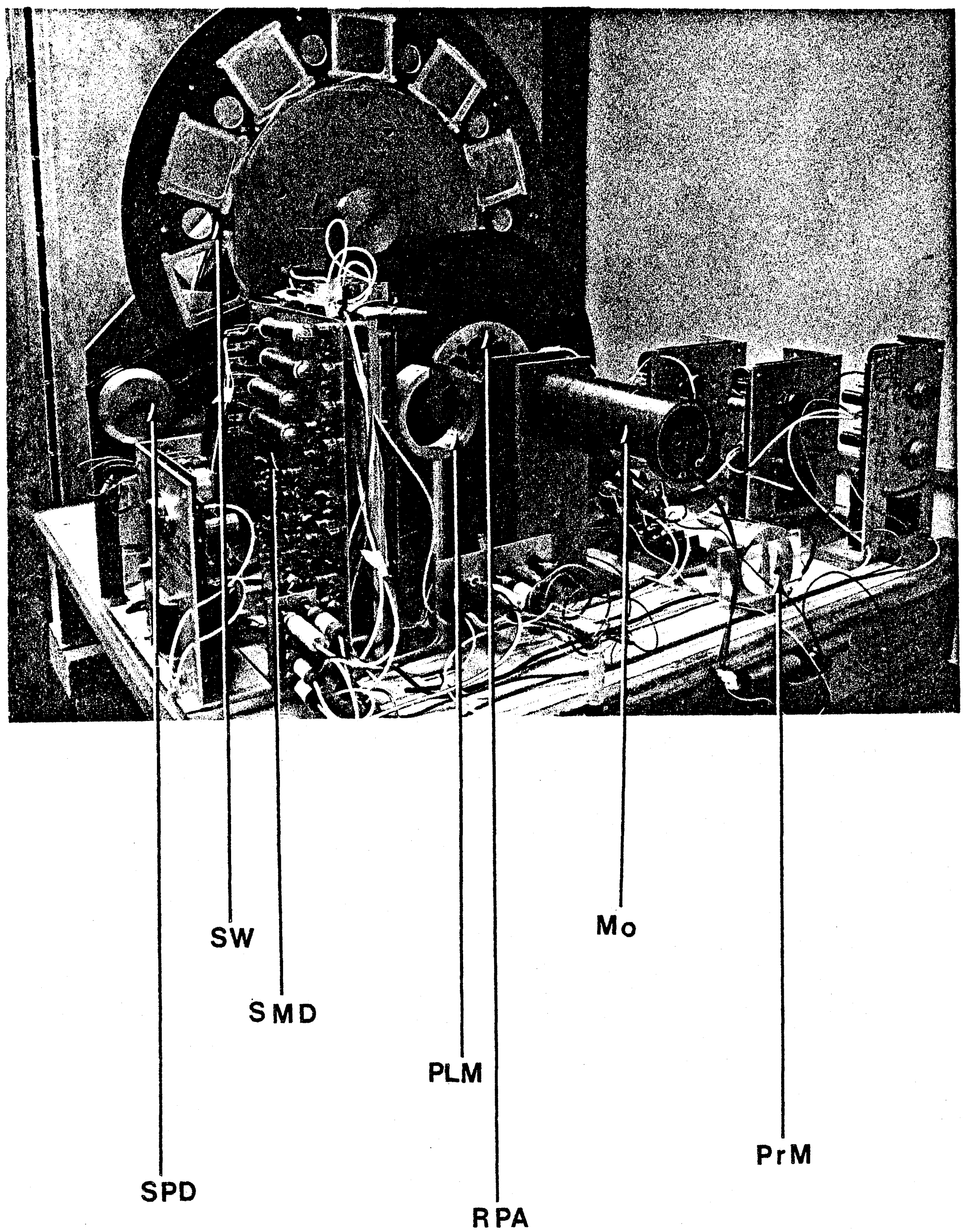

SW
Mo
SMD
PLM
PrM
SPD
RPA

Figure 5. Random access projector (front view).

SW	Slide wheel--rotated by a stepper motor (not shown) under control of hard wired logic (not shown)
RPA	Rotating polaroid analyzer--rotated when electronic clutch (not shown) engaged and braked when electronic clutch disengaged
Mo	Continuously running AC motor--driving electronic clutch (not shown) to rotate polaroid analyzer disc (RPA)
PrM	Base-to-base prism mount with prisms--shown attached to front of projector lens
PA	Phototransistor amplifier and analog-to-digital converter--interfaces slide position detector (not shown) with hard wired logic control

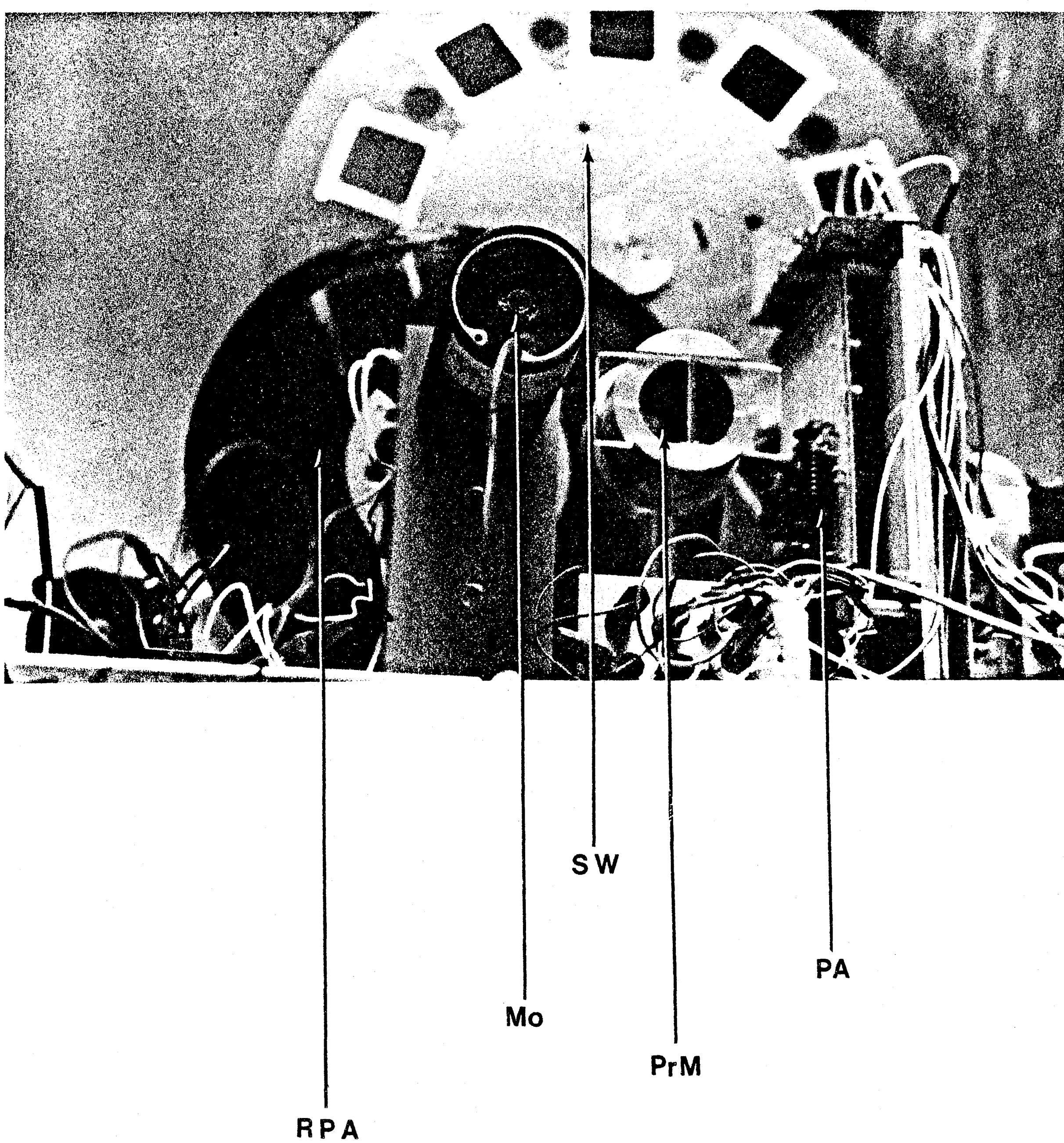

SW
PA
Mo
PrM
RPA

Figure 6. Random access projector (back side view).

SW	Slide wheel--rotated by a stepper motor (SM) under control of hard wired logic (not shown)
SM	Stepper motor--rotating slide wheel (SW) driven by stepper motor driver (not shown) and under the control of hard wired logic (not shown)
So	300 Watt ELH Halogen source with parabolic reflector
SoM	Source (So) mount with heat absorption plate (not shown)
HAPM	Heat absorption plate mount
CLM	Condensing lens mount
Fc	Condensing lens (CLM) - heat absorption plate (SoM and HAPM) cooling fan
Fs	Slide cooling fan
M	Mirror housing

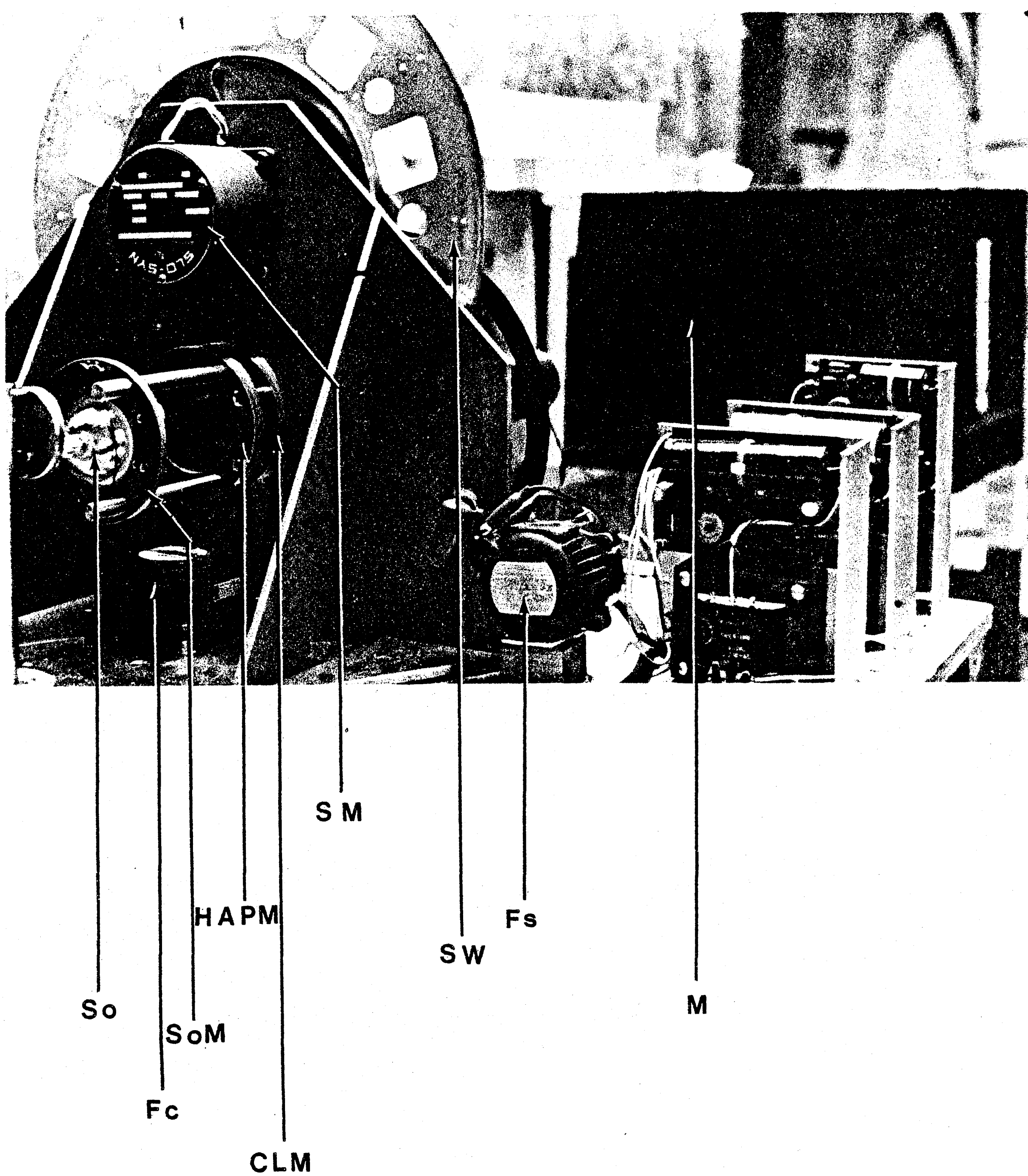
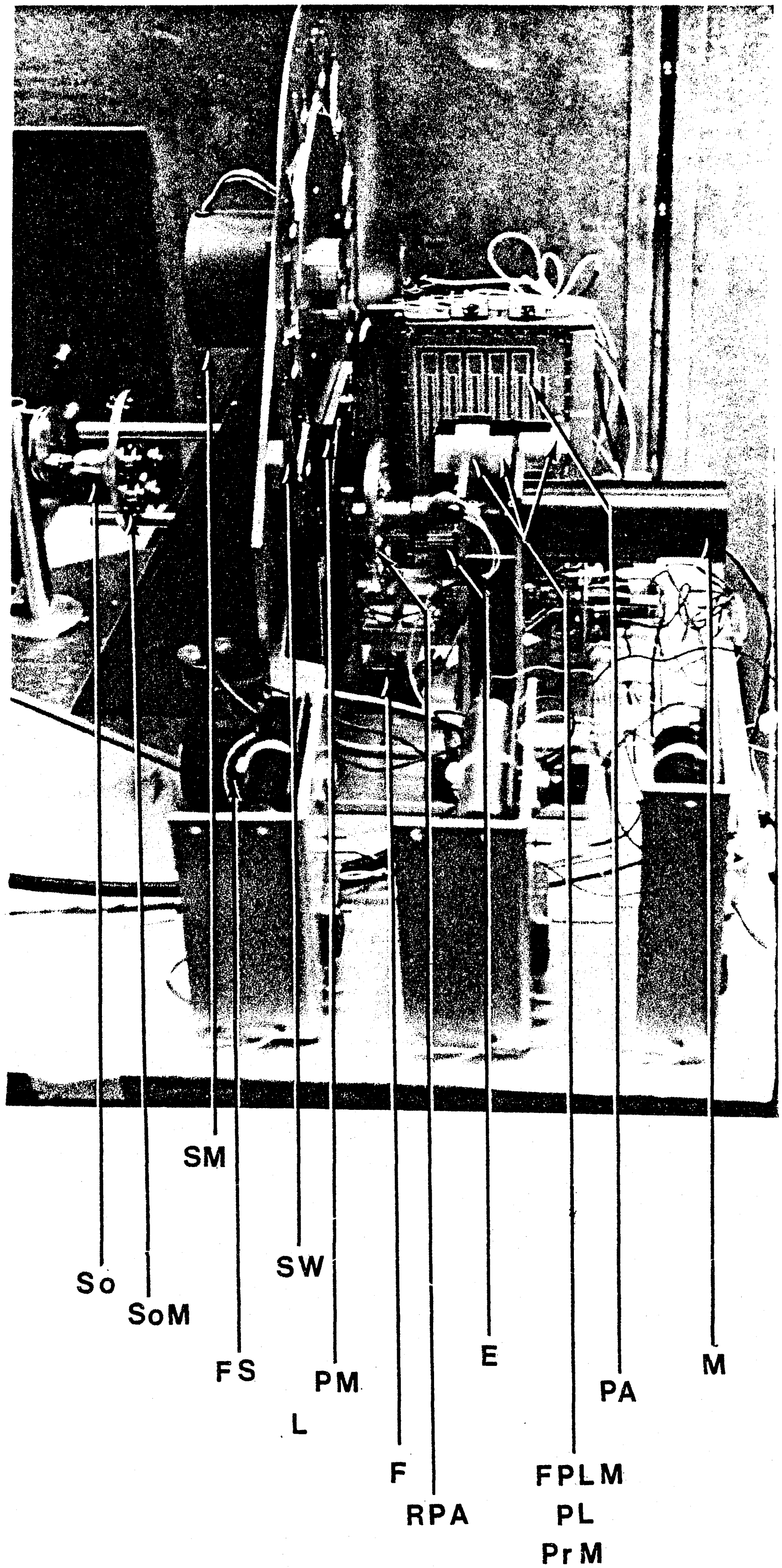

SM
HAPM
Fs
SW
So
M
SoM
Fc
CLM

Figure 7. Random access projector (side view).

So	300 Watt ELH Halogen source with parabolic reflector
SoM	Source (So) mount with heat absorption plate
SM	Stepper motor--rotating slide wheel (SW) and under control of hard wired logic (not shown)
SW	Slide wheel--rotated by stepper motor (SM) under control of hard wired logic (not shown)
FS	Slide cooling fan
PM	Polarizer mount--cross polarizing light transmitted from two slide fields (see text for further details)
RPA	Rotating polaroid analyzer--rotated when electronic clutch (E) engaged and braked when disengaged
E	Electronic clutch--under control of hard wired logic (not shown); driven by continuously rotating motor (Mo); rotates polaroid analyzer (RPA) when engaged and brakes rotating analyzer when disengaged
F	Feedback control for rotating polaroid analyzer disc (RPA)--consists of an infra-red emitting diode and phototransistor that triggers electronic clutch (E) disengagement
PLM, PL, PrM	Projector lens mount; 2.8, 3" f.l., short throw Kodak projector lens; base-to-base prism mount shown mounted on front of projector lens
PA	Phototransistor amplifier and analog-to-digital converter--interfaces slide position detector (not shown) with hard wired logic


SM
SW
So
SoM
FS
PM
L
E
M
PA
F
RPA
FPLM
PL
PrM

lens was a rotating, polarized analyzer (Figures 4, 5, and 7). By rotating the analyzer, slide fields could be alternately projected. Two base in, 8 diopter wedge prisms were affixed to the projecting end of the focusing lens (Figures 4, 5, and 7). This produced two images of each of the two slide fields; the center two exactly overlapping at the plane of a Kodak, black glass, rear projection screen (Figure 8).

The two flanking images were completely masked at the entrance part of the mirror housing (Figures 1, 2, and 6). Further, the central, overlapping images were masked at the mirror housing exit port to eliminate any border effects (Figure 8).

One field of the slide was clear. The other side contained a black line figure.* Stimulus presentation consisted of rotating the polaroid analyzer 180° (Figure 5), alternating from the blank field to the figure field, and back to the blank field. This allowed black line figures to be presented with minimal changes in background luminance.

Rotation of the analyzer was controlled by an electronic clutch attached to a continuously rotating electric motor (Figure 7). The clutch was engaged and disengaged by the hard wired logic controlling the projector (Figures 1 and 2).

Calibration and monitoring of the flash was done using a photo-

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*There were four exceptions to this. The "blank" control stimulus had no background and no figure. The "background only" control stimulus had no figure in either field. The "flash +" and "flash -" control stimuli had no figure and only one field.

Figure 8. Back projection screen.

This view shows the screen, with fixation guides (PS, FG) mounted on the mirror housing (M). The subject sat in a chair (Figure 9) to the right of the screen. The intercom (I) is shown attached to the inside wall of the shielded room.

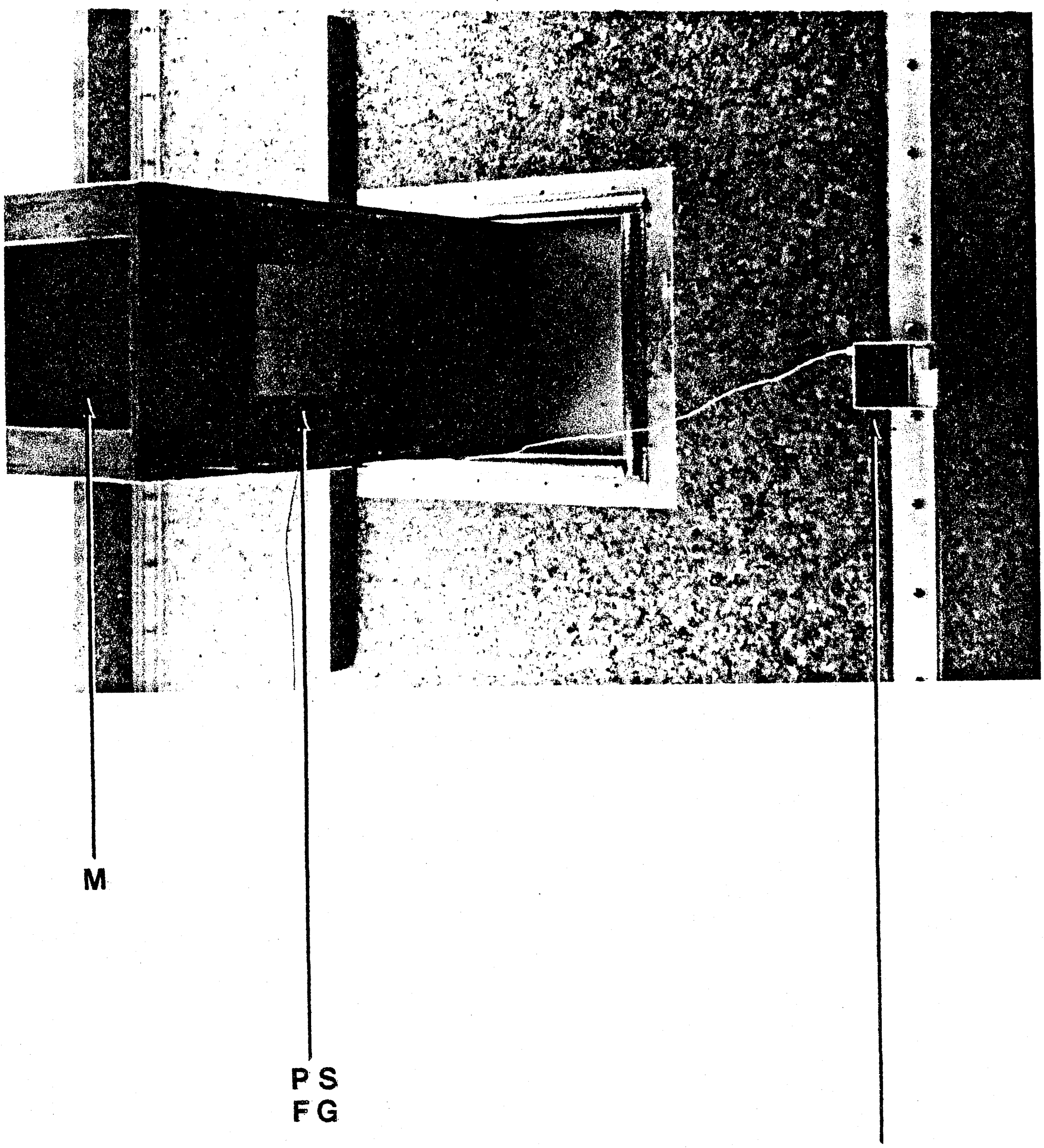
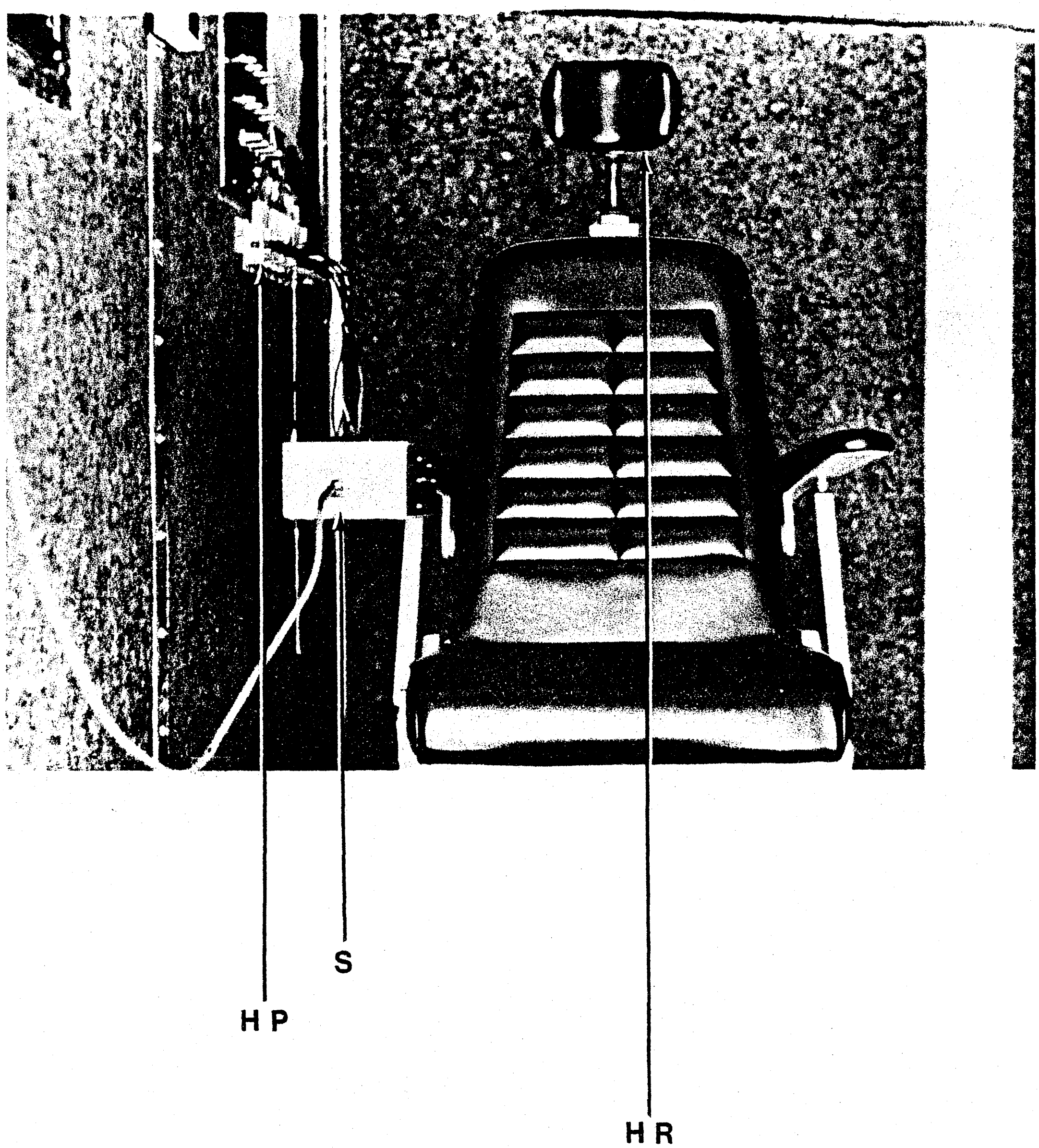

M
P S
F G
I

Figure 9. Subject's chair in shielded room

Subjects sat in this contoured chair, facing the back projection screen (not shown) within the shielded room. The adjustable head rest held the subject's head in position during data gathering. The switch box (S) conveyed a subject's interpretation of reversible figures to the experimenter. The switch box could be placed on either arm of the chair. Grass HIP511 high impedence probes are shown at the upper left (HP).


S
H P
H R

diode placed on the back projection screen. Photodiode output was monitored using an oscilloscope with the sweep triggered by the pulse to the computer initiating acquisition of an EEG record. One field of a slide was blanked, giving a sinusoidal light pulse (flash +), or sinusoidal background off pulse (flash -), when the system was operated. No systematic temporal differences between the flash + and flash- were measured. Initial response to light transmitted through the back projection screen (flash +) occurred 41.6 ms after the computer trigger. It peaked at 90.4 ms and returned to baseline at 143.2 ms. The oscilloscope trace looked completely sinusoidal. Variation from the above mean values was random. The entire range of values obtained was 40-44 ms for onset, 87-94 ms for peak, 141-145 ms for offset. These values were determined by several independent measurements made by three individuals over a period of one year.

Each 35 mm stimulus slide was made from three independently drawn replications of each figure. Each drawing was photographed on several rolls of Kodalith and separately developed. Stimulus slides were selected and discarded regularly so that variations in graphics and film processing would not be a factor in VER results.

Subjects sat in a chair with neck rest and arm rests. The neck rest was placed 3 cm or so below occipital electrodes and held the head firmly, but comfortably (Figure 9).

C. Stimuli

This study was separated into three parts: (1) presentation of

control stimuli; (2) presentation of geometrical, word and trigram stimuli; and (3) presentation of solid and reversible figure stimuli (Figure 10). The control stimuli consisted of a blank field stimulus (both figure and background slide fields covered), a background only stimulus (no figure in either slide field), a flash + stimulus (background field of slide covered), a flash - stimulus (figure field of slide covered) and a figure stimulus (a black line figure not used in other portions of the experiment in the slide figure field plus background field). See Figure 10 for the two control figures used.

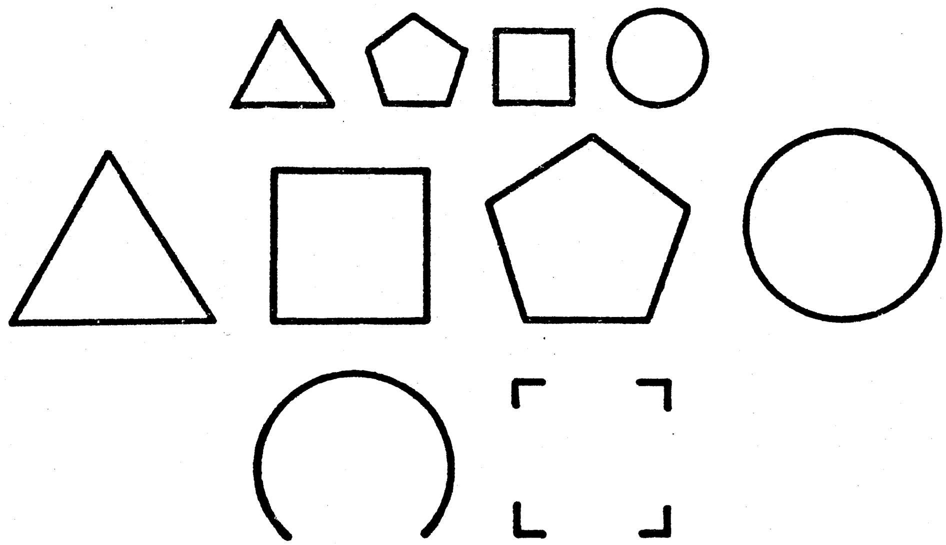
Four small and four large geometrical figures were used in part two: equilateral triangle, square, pentagon, and circle. All geometrical figures within a set had the same perimeter. Maximum angular subtense of each figure along the horizontal dimension was:

1. Small Triangle .... 52'
2. Small Square ...... 39'
3. Small Pentagon .... 51'
4. Small Circle ...... 50'
5. Large Triangle .... 105'
6. Large Square ...... 79'
7. Large Pentagon .... 104'
8. Large Circle 96'

Images were very slightly defocused giving vertical lines a maximum width of 11' of arc (as measured by change in Luminance with a

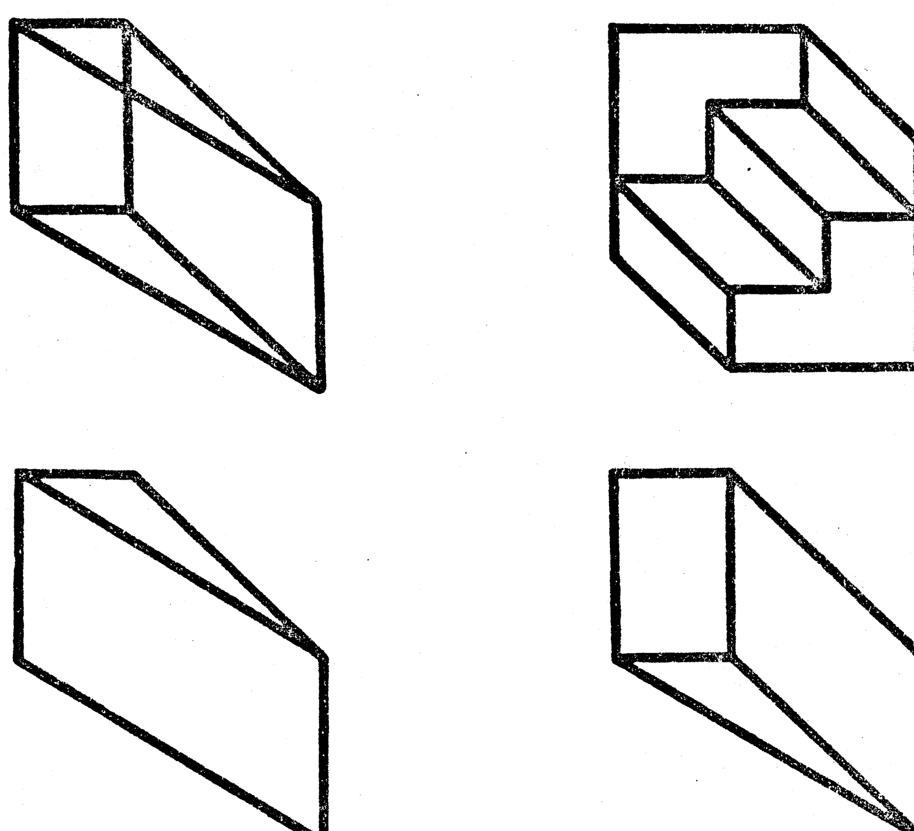
Figure 10. Stimuli.

These stimulus figures are all drawn to the same scale. The top row shows four small geometrical figures equated for perimeter. The four geometrical figures in the second row all have perimeters twice that of the small geometrical figures. The two control figures, third row, are the same size as the large geometrical figures. The meaningful trigrams and nonsense trigrams in row four were presented to all subjects, while those in row five were presented only to subjects JU and K. The small geometrical figures, large geometrical figures and the trigrams were combined with additional figures (see text and Appendix G) to form a group of thirty stimuli. Five stimuli at a time were randomly selected from this group, without replacement, and presented in single recording sessions in Part 2 of this study. The two reversible figures (row six) and the two solid figures (row seven) were always presented together in recording sessions forming Part 3 of this study.



WAR RAW RWA AWR

ART RAT RTA ATR



Spectra Pritchard photometer).* Horizontal lines measured a maximum width of 12' of arc. Diagonal lines measured 13' of arc. The average maximum contrast of the geometrical figure was 60% which occurred approximately 90 ms after the computer trigger.

Data from 4 trigrams presented to all subjects in part two of this study were WAR, RAW, AWR, and RWA. These trigrams subtended 47' of arc along the horizontal dimension. Their average maximum contrast was 64%. Additional data will be presented from trigrams ART, RAT, ATR, and RTA, shown to one subject. Figure 10 shows these stimuli.

Four figures were used in the third part of this study: a solid wedge viewed as pointing toward the subject, a solid wedge viewed as pointing away from the subject, a reversible wedge, and a reversible staircase, all subtended a maximum horizontal dimension of 1°38' of arc. Vertical, horizontal and diagonal lines for these figures measured 16' of arc in cross section (as measured by a Spectra Pritchard Photometer). These figures showed an average maximum contrast of 63% (Figure 10).

All stimuli were viewed against a 144 mm square white light background subtending 9°32' of arc on each side. Central fixation was maintained using 2 vertical and 2 horizontal fixation guides. These guides were constantly displayed. Each guide projected from an edge toward the center of the field; each length subtending 2°52' of

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*Measurements were made with a Spectra Pritchard Photometer with 2' field, a movable slit placed on the back projection screen, and a millimeter rule.

arc. This left a clear central viewing area subtending 3°52' X 3°52', within which all stimuli were presented (Figure 8).

Average Luminance measurements of the central 3° of the background as a function of analyzer rotation were:

360° & 0°	.........22.7 cd/m^2 ± 1 cd/m^2
45°	.........23.6 cd/m^2
90°	.........25.7 cd/m^2
135°	.........24.2 cd/m^2
180°	.........23.4 cd/m^2
225°	.........24.4 cd/m^2
270°	.........25.7 cd/m^2
315°	.........24.0 cd/m^2

Bulb changes and operation time produced small changes which ranged over ± 1 cd/m^2 during the months of this study. The luminance changes in the background as a consequence of analyzer rotation were sinusoidal, with a period of 180°, peaks at 90° and 270°, and minimums at 0°, 360° and 180°. Whether a particular presentation of a stimulus resulted from 0-180° or 180°-360° rotation of the analyzer was random.

D. General Procedures

Most elements of the experimental procedures in the three parts of this study were the same. Preparation time always required about one hour and immediately preceded each run. Electrode placement was determined by measurement of the scalp during every session. Six electrodes were placed in accord with the International 10-20 Elec-

trode Placement System: F_7, F_8, P_3, P_4, O_1, O_2. F_7 is roughly over Brocha's area, P_3 and P_4 over visual association area 39, and O_1 and O_2 over primary visual cortex. Variation in electrode placement was small (always within a 1 cm diameter circle) from week to week. Linked ear lobes served as reference. Ground was placed on the subject's forehead (Figure 1).

Foam rubber, jet mechanic ear plugs were placed in both ears and allowed to expand into the ear canal. Headphones were placed over both ears. Electrode impedances were then checked.

Subjects sat in a contoured chair facing the back projection screen. The neck rest was placed to hold the head firmly, but not to interfere with the occipital electrodes. The viewing distance of 86 cm was checked and electrodes connected to the high impedance probes.

EEG was tested on a monitor scope. Subjects were instructed to move their eyes up and down to check effects of eye movements. F_7 and F_8 EEG served as a general indicator of subject eye movements and was sensitive to 3° changes in fixation.

Stimuli were then presented to the subject. He was asked to identify each two or three times. Any preliminary problems in procedure were corrected at this time.

Subjects always viewed the stimulus binocularly. Subjects were asked to recognize each stimulus, but not to vocalize, subvocalize, or otherwise respond when a stimulus was presented. Preliminary training regarding these VER contaminants eliminated them to

whatever extent is possible. There is no reason to believe that any of these problems occurred during data gathering sessions.

Data gathering immediately followed initial hookup and equipment testing. Each stimulus presentation was initiated by the experimenter selecting a predetermined stimulus. The sequence of events that followed were under hard wired logic control. Following each stimulus presentation the experimenter viewed each EEG record for indication of stimulus artifact. If there was any, the presentation was rejected.

The stimulus presentation was always preceded by the onset of the adapting field. The duration of the adapting field varied randomly between 2 and 6 seconds preceding stimulus presentation.

The random stimulus presentation sequence continued until each stimulus had been presented the required number of times for averaging. The computer automatically terminated each session. Each session was followed by a fairly informal debriefing to discuss any problems that came up during a session.

E. Control Stimulus Procedures

Control stimuli were presented during the first session for each subject, during two intervening sessions, at convenient times, and during the last session for each subject. Each record from a control session consisted of 32 stimulus presentations.

Control stimuli presented special problems for subjects because a flash was included among the stimuli. Blinking, squinting, anticipatory muscle responses and anticipatory brain responses plagued every

subject. As a consequence, particular attention was paid during preliminary training of subjects to eliminating these artifacts. Records obtained during control stimulus sessions generally indicate that these artifacts were brought under control.

F. Geometrical Figure and Trigram Stimulus Procedures

Thirty stimuli were presented and replicated during these sessions (see Appendix G for a complete listing of stimuli). Five stimuli were randomly selected five at a time without replacement for each subject. Five stimuli were then presented during each of six successive sessions. This entire selection and presentation procedure was then replicated for each subject for a subsequent 6 sessions. Each record obtained from each session consisted of 32 stimulus presentations. No variations from the general procedures were used.

G. Solid and Reversible Figure Stimulus Procedures

The general procedures for this part of the study were modified in only three ways: (1) Subjects were required to respond following a stimulus presentation by pressing a button indicating interpretation of the stimulus; (2) a brief buzz followed each stimulus presentation by no less than two and no more than fifteen seconds, indicating that the subject should press the button; and (3) the experimenter assigned the EEG record to the appropriate matrix position for averaging by the computer, or rejected the record based on artifact, incorrect interpretation of a solid or type of reversible figure, or a subject's response indicating ambiguity.

Preceding data collection sessions each subject had four training sessions. The purpose of these sessions was to train subjects to relax with a hand on the switch box, attend to the stimulus, await the buzzer, and then select the correct button to indicate stimulus interpretation. Further, subjects were trained to do this task with either hand. As no mistakes were observed from any subject during data collection, training may be assumed to have been effective.

A VER record from each stimulus was the average of 8 accepted stimulus interpretations. Subject response hand was alternated so that the same hand was used every other session. There were 8 data collecting sessions.

RESULTS

All VERs were initially summed (based on 32 EEG records) and averaged ($\overline{\Sigma 32}$). Following this procedure the data was digitally filtered by setting all frequency and phase values beyond 29 Hz to 0. Figure 11 shows one of subject K's digitally filtered F_7 recordings (No. 29) and the first 16 (0 - 15) frequency components summed to make the waveform (No. 15). The general analysis procedure is outlined in Appendix A.

A. Control Data

Two of the replicated $\overline{\Sigma 32}$ VERs are shown for each control stimulus from subjects K and JU in Figures 12 and 13. It is particularly notable that subject K showed a small, slow late VER component at electrode sites P_3, P_4, O_1, and O_2 resulting from presentation of the blank stimulus. This was absent in the other two subjects and may be a consequence of expectation of stimulus presentation. No other contributing factor could be found.

The general form of VERs was highly replicable for subjects over a period between recording sessions of nearly one year. However, there is also considerable variability in the data that must be taken into account when small or subtle differences between VERs are to be considered.

Figure 14 shows VERs resulting from the mean of two of subject JU's $\overline{\Sigma 32}$ VERs recorded during separate sessions. Blank VERs for subject JU are quite flat, as were those of subject JI.

A comparison of Background Only and Figure VER records indicates

Figure 11. Frequency Components of Digitally Filtered F_7 VER.

Sixteen frequency components of a digitally filtered F_7 VER obtained from subject K are shown. The numbered values on the right show the cumulative sum of components to and including that number on the left. The VER record labeled 29 shows the digitally filtered VER with all components above 29 Hz set to zero.

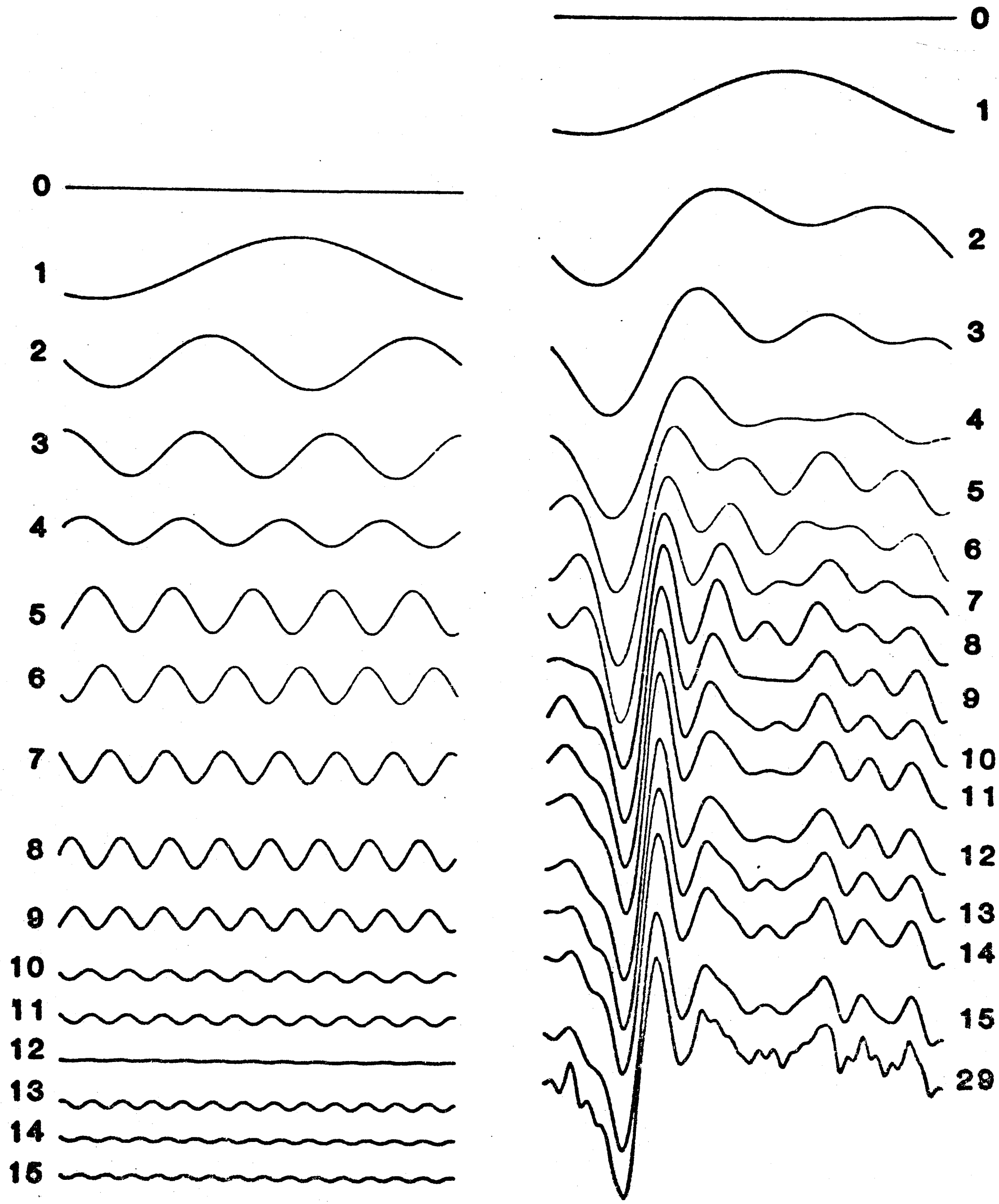

0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
29

Figure 12. Control Data Obtained from Subject K During Two Sessions Separated by 9 Months

Each VER is the averaged result of 32 stimulus presentations. Electrode positions are shown across the top of the figure. The "Blank" stimulus resulted when both the adapting and figure fields of the 35 mm slide were covered. The "Background Only" stimulus was produced by eliminating the figure from the figure field. The "Figure" stimulus was a partial circle, open at the base. The only difference between the "Background Only" and "Figure" stimulus was the black line figure. The Flash -" was produced by covering the figure field while the "Flash +" was produced by covering the adapting field and eliminating the figure from the figure field.

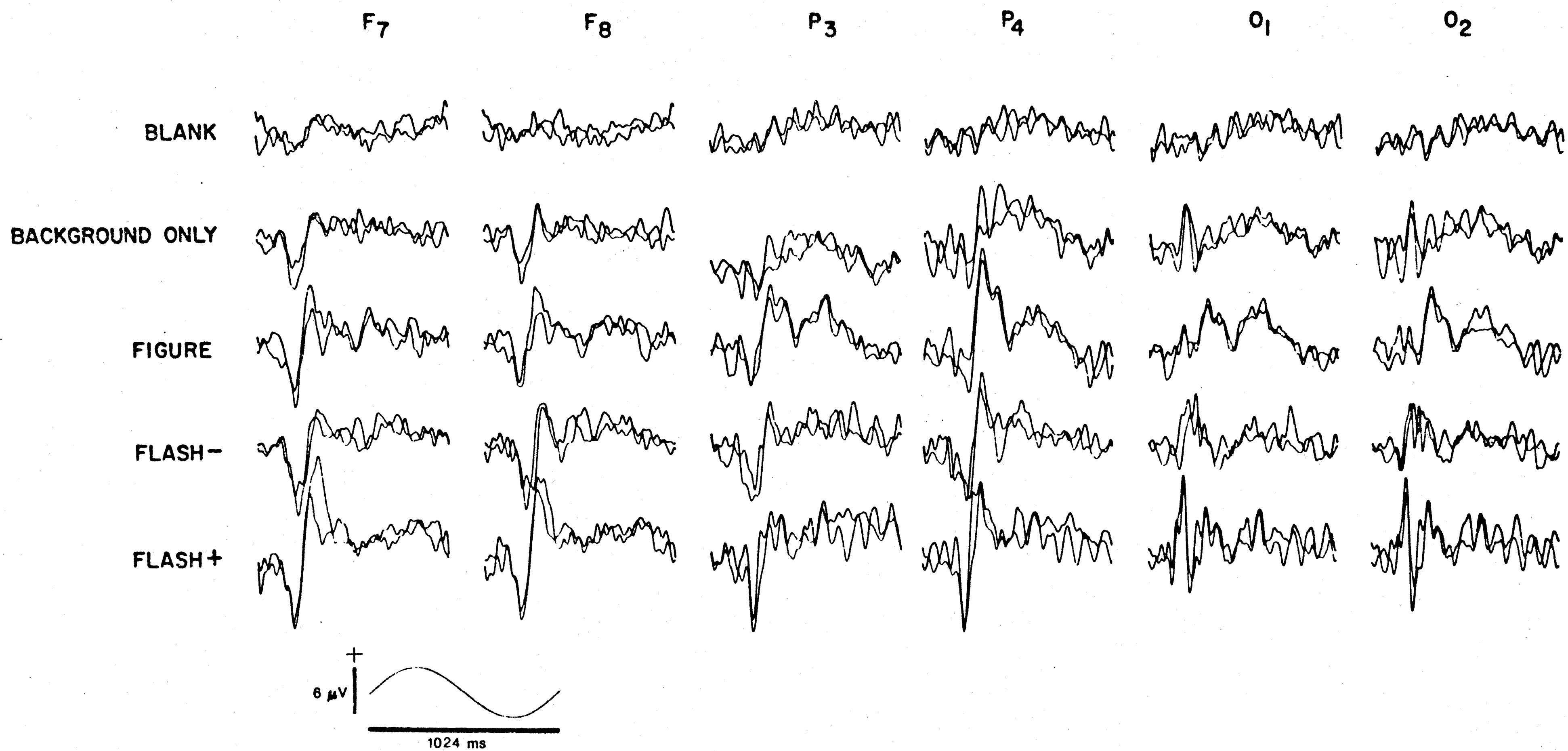

F7
F8
P3
P4
O1
O2
BLANK
BACKGROUND ONLY
FIGURE
FLASH-
FLASH+
+
6 µV
1024 ms

Figure 13. Control Data Obtained from Subject JU During Two Sessions Separated by Approximately 11 Months.

Each VER is the averaged result of 32 stimulus presentations. Electrode positions are shown across the top of the figure. The "Blank" stimulus resulted when both the adapting and figure fields of the 35 mm slide were covered. The "Background Only" stimulus was produced by eliminating the figure from the figure field. The "Figure" stimulus was the corners of a large square. The only difference between the "Background Only" and the "Figure" stimulus was the black line figure. The "Flash −" was produced by covering the figure field while the "Flash +" was produced by covering the adapting field and eliminating the figure from the figure field.

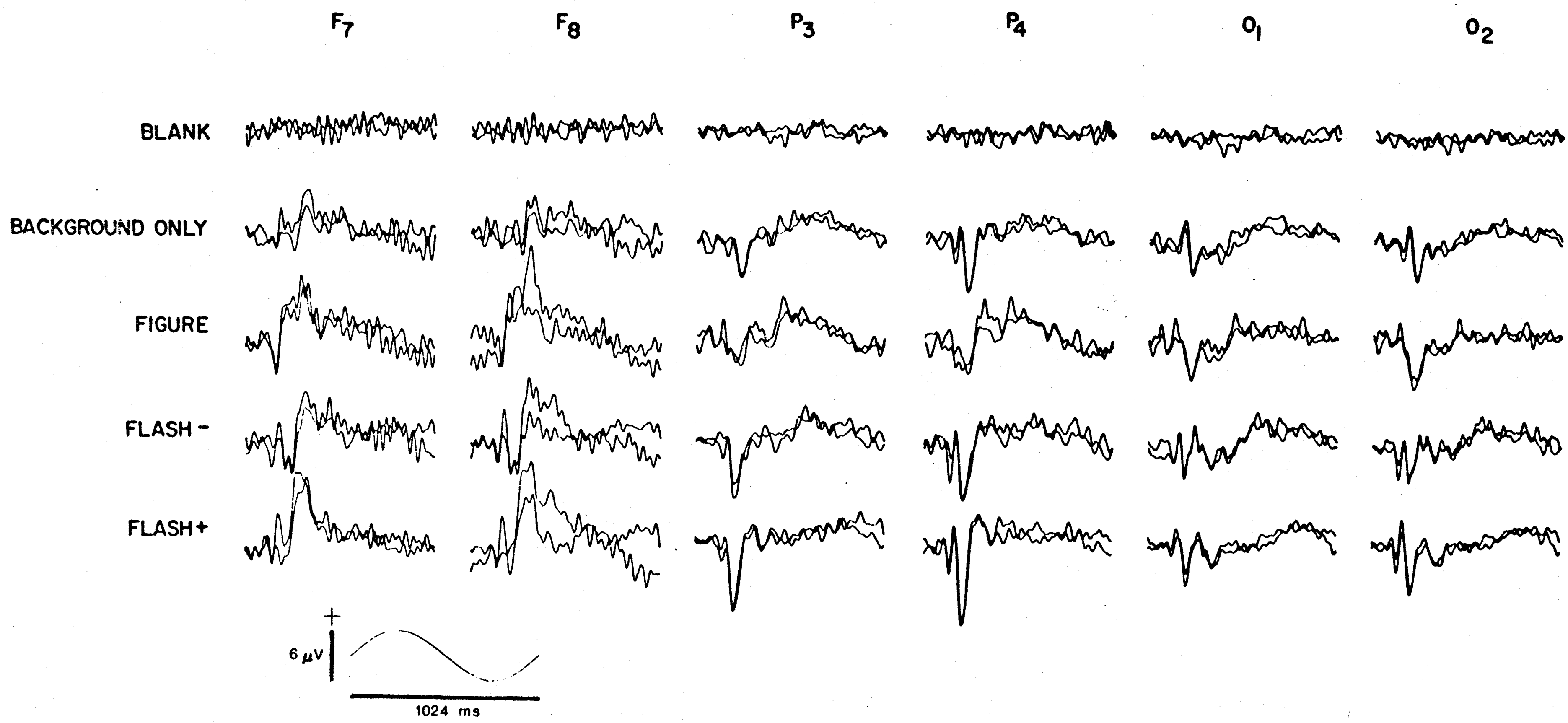
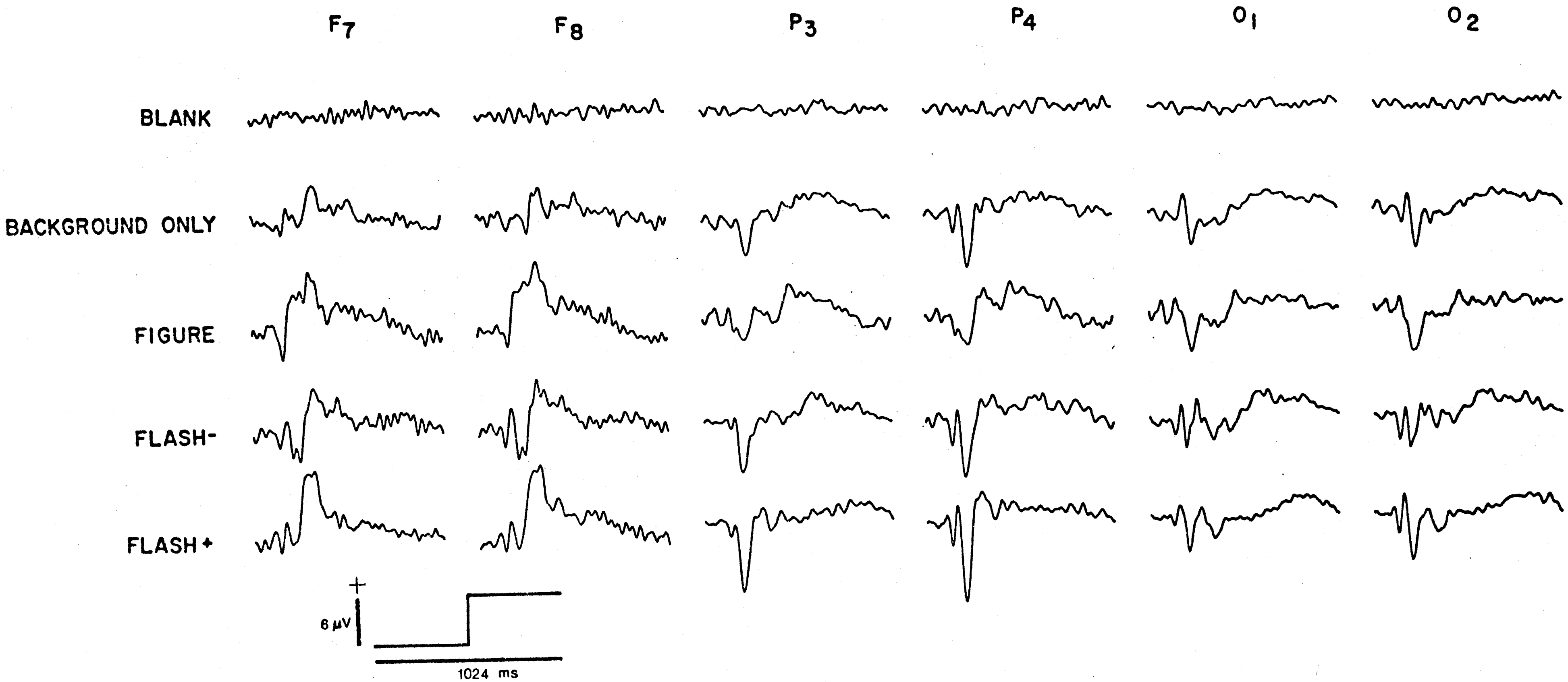

F7
F8
P3
P4
O1
O2
BLANK
BACKGROUND ONLY
FIGURE
FLASH -
FLASH +
+
6 μV
1024 ms

Figure 14. Control Data Obtained from Subject JU, Combined from Two Sessions.

Each $\overline{\Sigma 64}$ VER from subject JU is the average of two digitally filtered $\overline{\Sigma 32}$ VERs; one obtained October 30, 1977, the other October 8, 1978. Electrode positions are shown across the top of the figure. The "Blank" stimulus resulted when both the adapting and figure fields of the 35 mm slide were covered. The "Background Only" stimulus was produced by eliminating the figure from the figure field. The "Figure" stimulus was a horseshoe shape. The only difference between the "Background Only" and the "Figure" stimulus was the black line figure. The "Flash -" was produced by covering the figure field while the "Flash +" was produced by covering the adapting field and eliminating the figure from the figure field.


F7
F8
P3
P4
O1
O2
BLANK
BACKGROUND ONLY
FIGURE
FLASH-
FLASH+
+
6 μV
1024 ms

a consistent difference in appearance at all electrode sites. A comparison of Background Only, Figure, Flash + and Flash − VERs shows that the contribution of the background is not saturating the VER. This is absolutely essential if figure effects are to be compared.

Figures 15 and 16 show the variability in VERs for each subject resulting from presentation of the following stimuli: Small Square (SS), WAR, Large Circle (LO) and AWR. This data is from the second part of this study and represents superimposed $\overline{\Sigma 32}$ VERs from replications of the same stimulus.

Figure 17 summarizes results of control data comparisons using the waveform analysis described in Appendix A. Each digitally filtered $\overline{\Sigma 32}$ VER, A_i, resulting from a particular stimulus, i, was replicated, A_i', during a different recording session. Differences between the amplitudes of each frequency component were calculated ($|a_{im}|\Big|_{m=1}^{m=29}$). The mean of each digitally filtered $\overline{\Sigma 32}$ VER and its replication was calculated, producing a $\overline{\Sigma 64}$ VER, B_i. A difference in waveform between two $\overline{\Sigma 64}$ VERs, B_j and B_k, resulting from two different stimuli, $j \neq k$, was determined in the following way:

1. The difference in amplitude between each frequency component of VERs B_j and B_k was determined ($|b_{jk1}|$, $|b_{jk2}|$, $|b_{jk3}|, \ldots, |b_{jk29}|$)
2. If at least one amplitude difference $|b_{jkm}| > |a_{jm}|$ and $|b_{jkm}| > |a_{km}|$; Then B_j and B_k are different in waveform.

Figure 15. $\overline{\Sigma 32}$ VERs Obtained from a Large Circle (LO) and the Trigram AWR.

Replications from each subject are superimposed. Electrode positions are given across the top of the figure. Subject, followed by stimulus, labels each row (K, LO). These data are representative of VERs obtained in the second part of this study, showing variability resulting from replication.

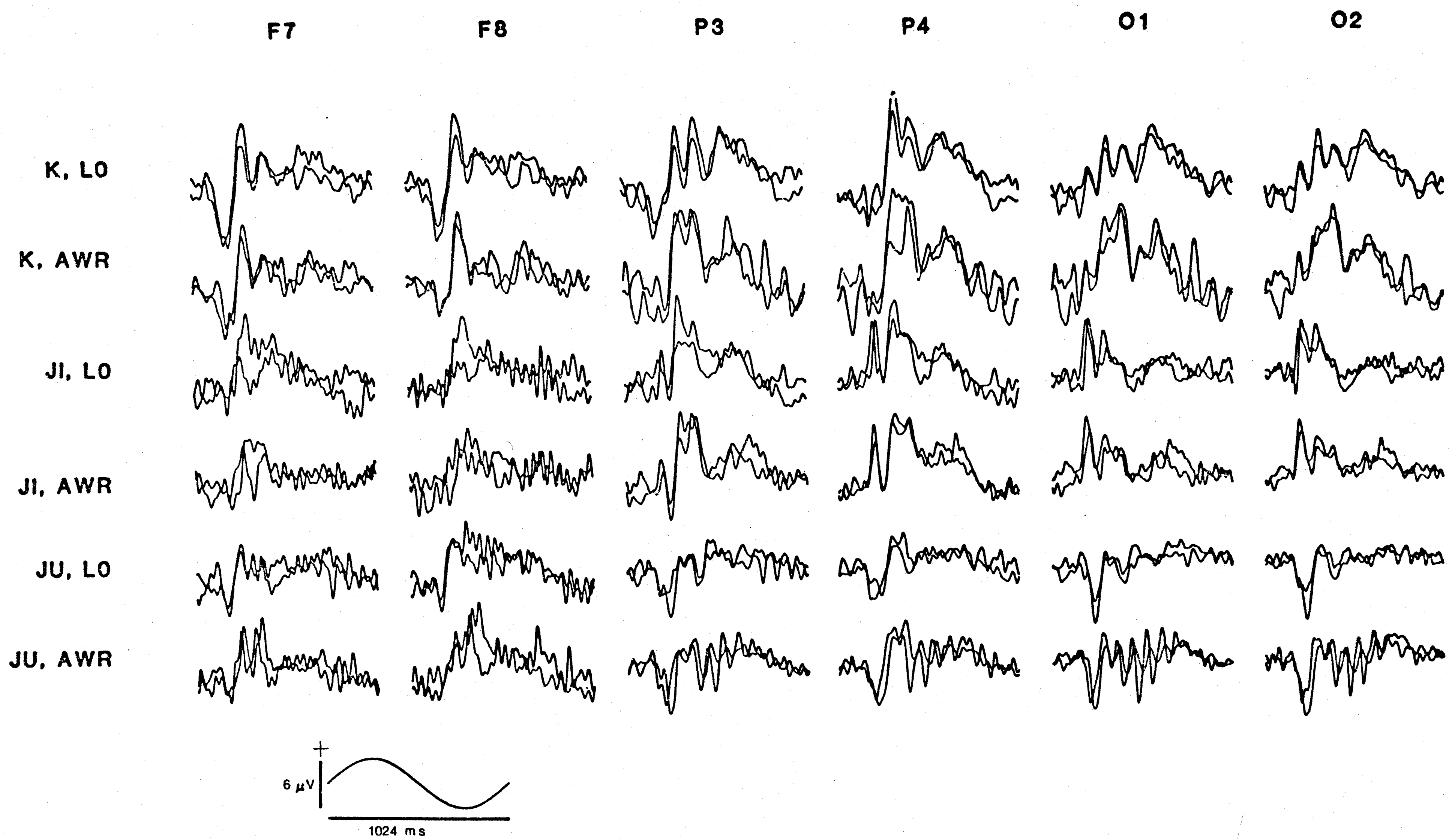

F7
F8
P3
P4
O1
O2
K, LO
K, AWR
JI, LO
JI, AWR
JU, LO
JU, AWR
+
6 μV
1024 ms

Figure 16. $\overline{\Sigma 32}$ VERs Obtained from a Small Square (ss) and the Trigram WAR.

Replications from each subject are superimposed. Electrode positions are given across the top of the figure. Subject, followed by stimulus, labels each row (K, ss). These data are representative of VERs obtained from the second part of this study, showing variability resulting from replication.

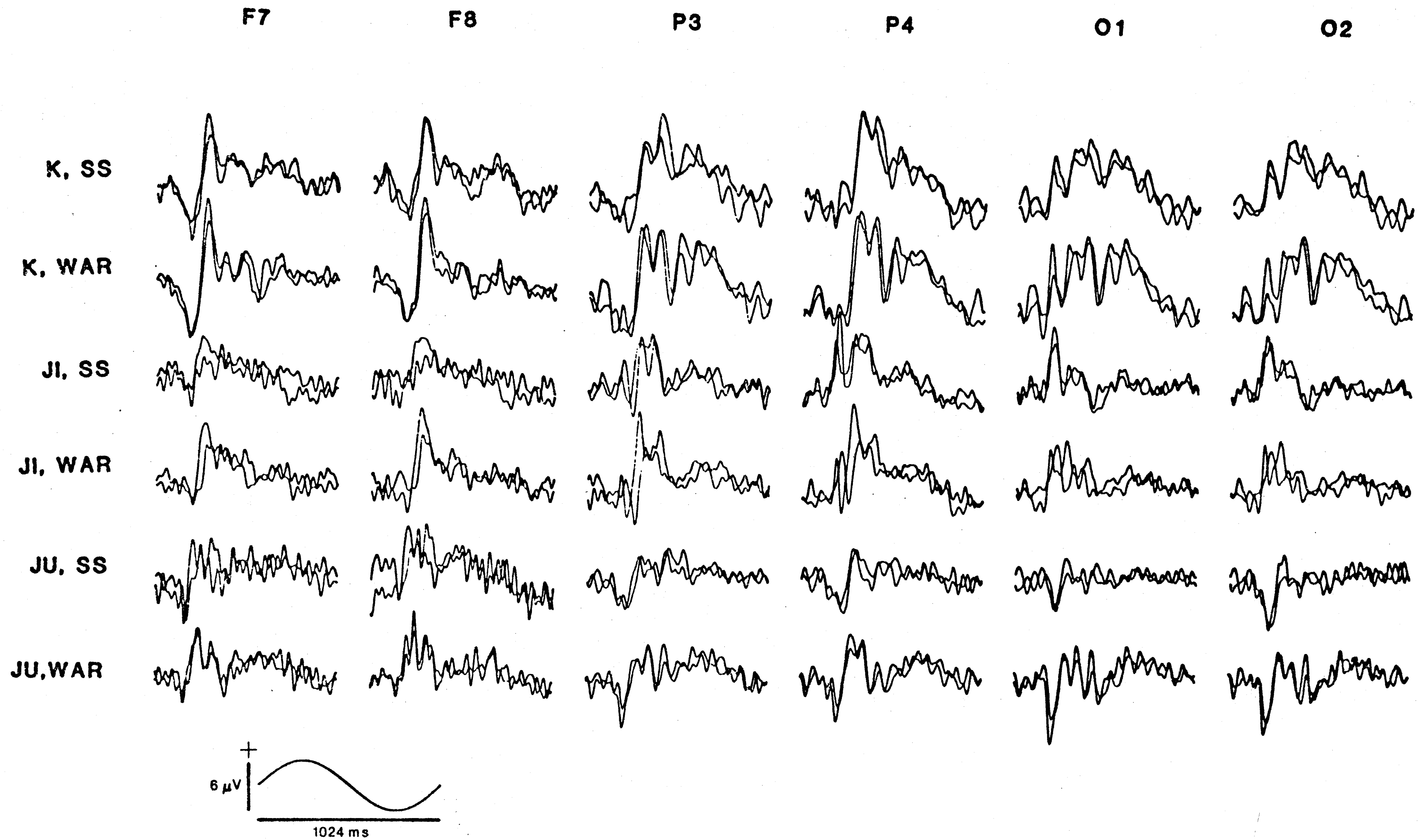
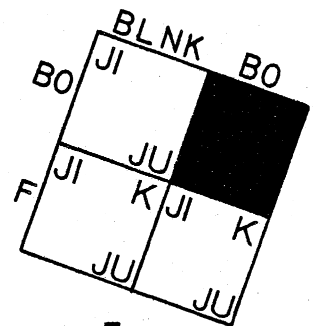
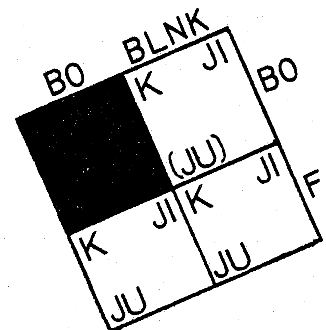

F7
F8
P3
P4
O1
O2
K, SS
K, WAR
JI, SS
JI, WAR
JU, SS
JU,WAR
+
6 µV
1024 ms

Figure 17. Binary Arrays for the Control Data Comparisons Given in Appendix C.

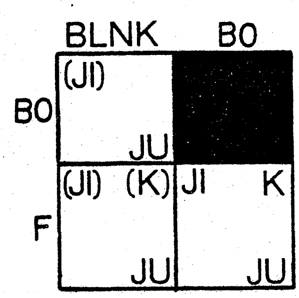
VER comparisons are between stimuli listed in a row and a column that is not crossed out. For example, differences were taken between the Background Only (BO) $\overline{\Sigma 64}$ VER and Blank (BLNK) $\overline{\Sigma 64}$ VER at electrode site F_7. Based on the 0.1 x (error range associated with each frequency component) criterion, subjects JU and JI showed a difference. Subject K did not. Bracketed subject symbols represent particularly great differences (>1.0 µV or 5 or more frequencies above criterion). For example, differences between the Blank $\overline{\Sigma 64}$ VER and the Control Figure (F) $\overline{\Sigma 64}$ VER at electrode site P_4 were particularly large for subjects K and JI, but not for subject JU.



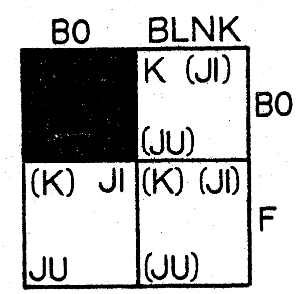
F_7



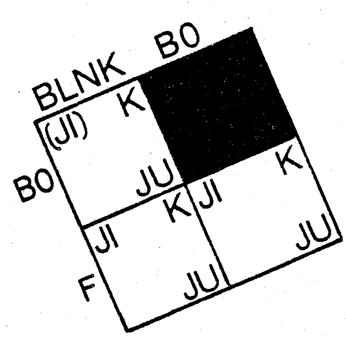
F_8



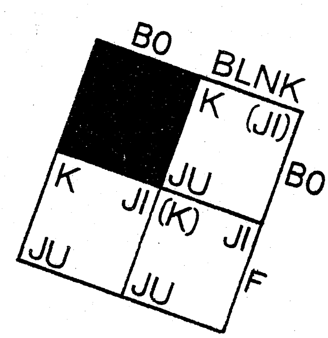
P_3



P_4



O_1



O_2

The criterion for entrance into the binary table is that at least one amplitude difference $|b_{jkm}|$ is greater than both $|a_{jm}|$ and $|a_{km}|$ by 0.1 x (error range associated with that frequency component m). This criterion is compatible with the differences shown between the Background Only VERs and the Figure VERs. This general range of differences above "error" would be the expected range of meaningful differences between VERs derived from different figures. The difference values required above the maximum replication difference at each frequency for stimuli to be compared was:

μV		Frequency
	Subject K	
> 0.3	at	1 Hz
0.2	at	2 Hz
0.2	at	3 Hz
> 0.2	between	4-12 Hz
0.1	Between	13-29 Hz
	Subject JI	
0.3	at	1 Hz
0.2	at	2-3 Hz
> 0.1	between	4-12 Hz
0.1	between	13-29 Hz
	Subject JU	
> 0.2	at	1 Hz
0.2	at	2 Hz
> 0.1	between	3-12 Hz
0.1	between	13-29 Hz

Statistical tables describing these comparisons are given in Appendix C. Differences between "Blank," "Figure" and "Background Only" VERs are shown for every subject at every electrode site (Figure 17). Greatest differences, bracketed in the Binary Array, are concen-

trated at the P_3 and P_4 electrode sites.

B. Geometrical Figure Comparisons

The mean of each digitally filtered $\overline{\Sigma 32}$ VER and its replication ($\overline{\Sigma 64}$ VER) is shown for each geometrical figure and each subject in Figures 18 through 23. Figure 24 shows the binary array resulting from geometrical figure comparisons given in Appendix D. Table 1 summarizes the same information, but with comparisons ordered from greatest to least overall difference. The criterion for entrance into the binary array is the same as that for the control stimuli.

The comparison across subjects shows that VERs obtained from different stimuli are consistently different in waveform. However, many individual differences are evident. Only subject K's F_7 VERs resulting from the Large Pentagon (LP) and from the Large Circle (LO) were different from each other. However, all three subjects showed a difference with respect to the F_8 electrode. Subject K did not show such a difference with respect to the P_3 electrode, but subjects JI and JU did. Only subject K showed a difference with respect to electrode site O_1; only subject JU at electrode site O_2.

Differences were found between the Small Circle (SO) and Small Square (SS) for every subject at every electrode site except one, O_2. At electrode site O_2 differences were shown for two subjects, JI and JU. The Small Triangle (ST) versus Small Circle showed the same pattern of differences. However, such consistency did not hold for the same geometrical forms of larger angular subtense. Only

Figure 18. Subject K's $\overline{\Sigma 64}$ VERs Resulting from Small Geometrical Figures.

ST stands for Small Triangle; SS for Small Square; SP for Small Pentagon; and SO for Small Circle. Electrode sites F_7, F_8, P_3, P_4, O_1 and O_2 are shown across the top of the figure.

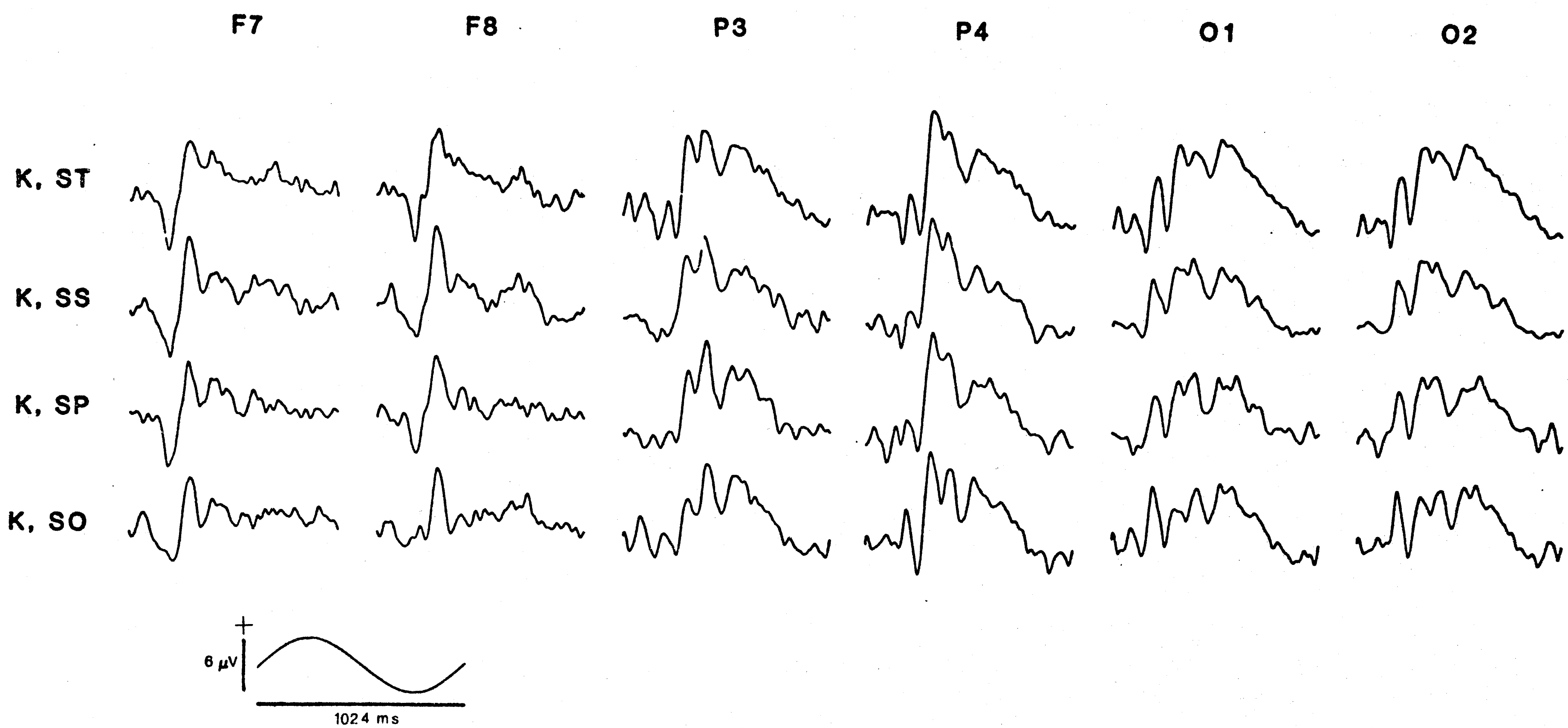

F7
F8
P3
P4
O1
O2
K, ST
K, SS
K, SP
K, SO
+
6 μV
1024 ms

Figure 19. Subject K's $\overline{\Sigma 64}$ VERs Resulting from Large Geometrical Figures.

LT stands for Large Triangle; LS for Large Square; LP for Large Pentagon; and LO for Large Circle. Electrode positions F_7, F_8, P_3, P_4, O_1 and O_2 are shown across the top of the figure.

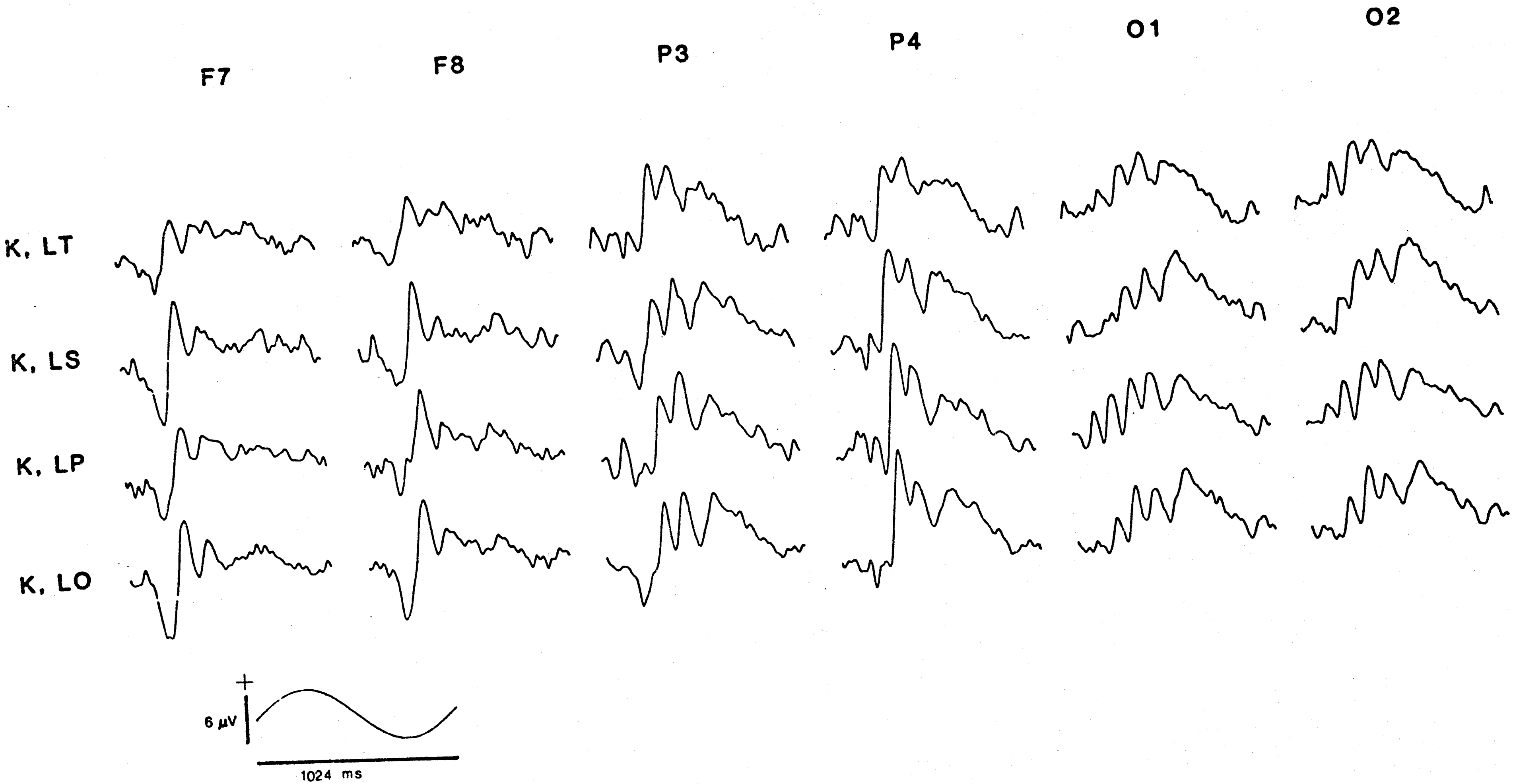

F7
F8
P3
P4
O1
O2
K, LT
K, LS
K, LP
K, LO
+
6 µV
1024 ms

Figure 20. Subject JI's $\overline{\Sigma 64}$ VERs Resulting from Small Geometrical Figures.

ST stands for Small Triangle; SS for Small Square; SP for Small Pentagon; and SO for Small Circle. Electrode positions F_7, F_8, P_3, P_4, O_1 and O_2 are shown across the top of the figure.

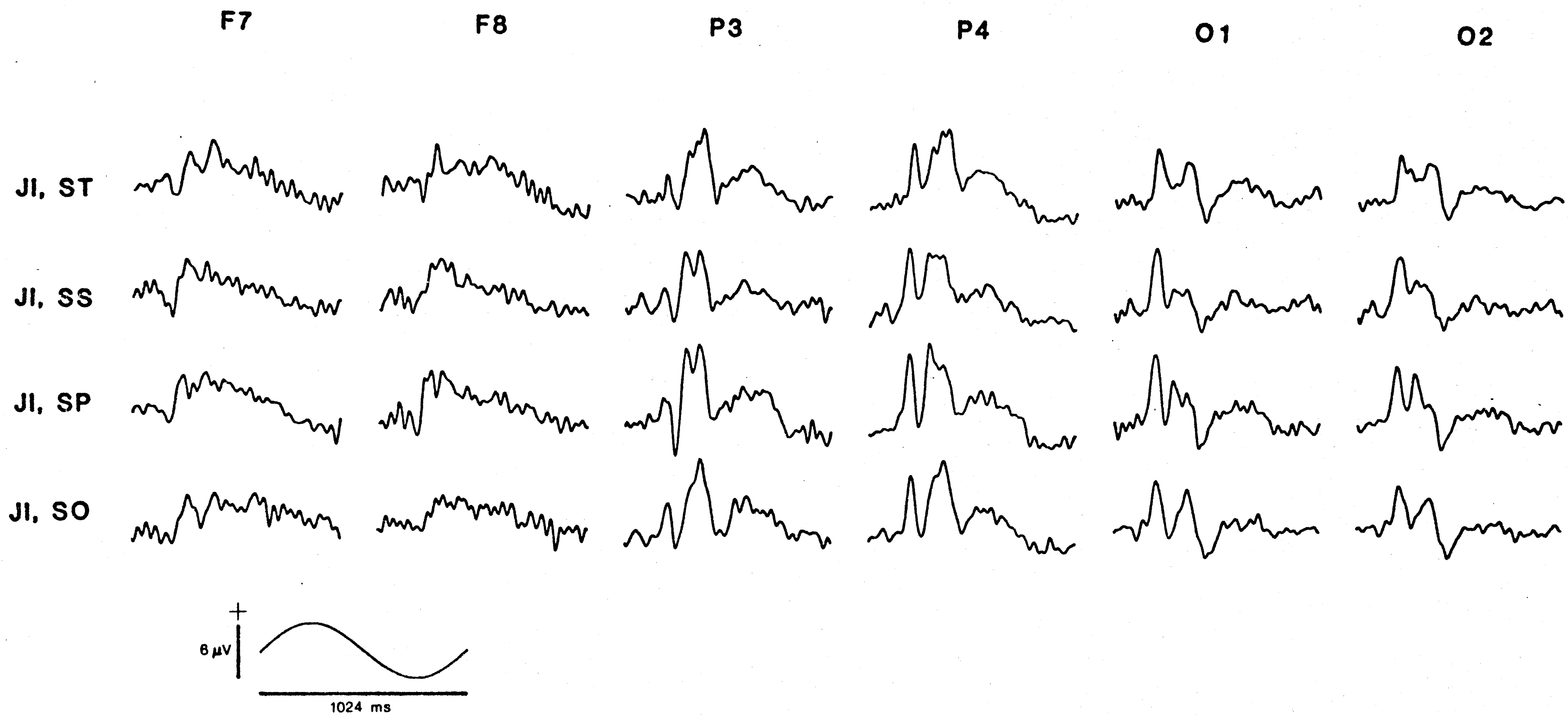

F7
F8
P3
P4
O1
O2
JI, ST
JI, SS
JI, SP
JI, SO
+
6 μV
1024 ms

Figure 21. Subject JI's $\overline{\Sigma 64}$ VERs Resulting from Large Geometrical Figures.

LT stands for Large Triangle; LS for Large Square; LP for Large Pentagon; and LO for Large Circle. Electrode sites F_7, F_8, P_3, P_4, O_1 and O_2 are shown across the top of the figure.

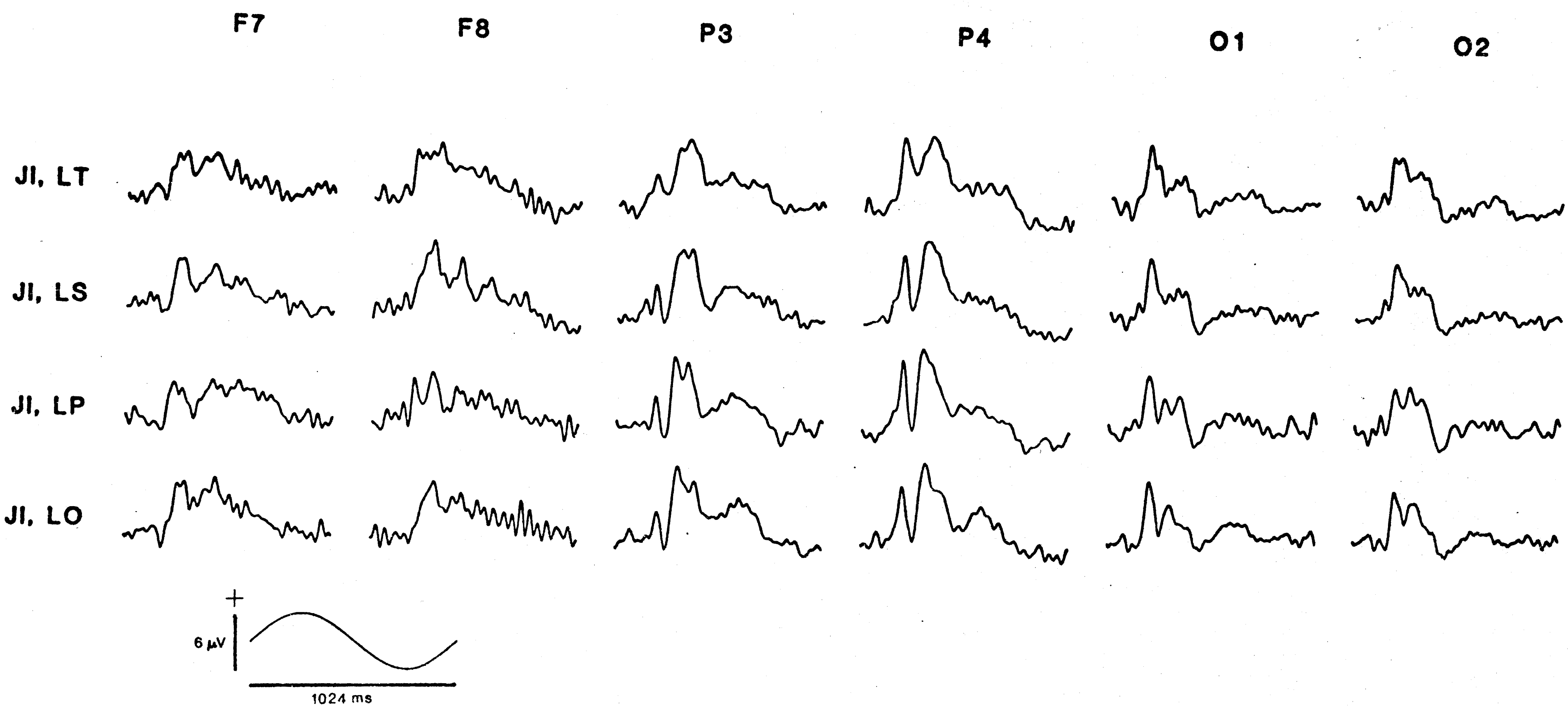

F7
F8
P3
P4
O1
O2
JI, LT
JI, LS
JI, LP
JI, LO
+
6 μV
1024 ms

Figure 22. Subject JU's $\overline{\Sigma 64}$ VERs Resulting from Small Geometrical Figures.

ST stands for Small Triangle; SS for Small Square; SP for Small Pentagon; and SQ for Small Circle. Electrode positions F_7, F_8, P_3, P_4, O_1, and O_2 are shown across the top of the figure.

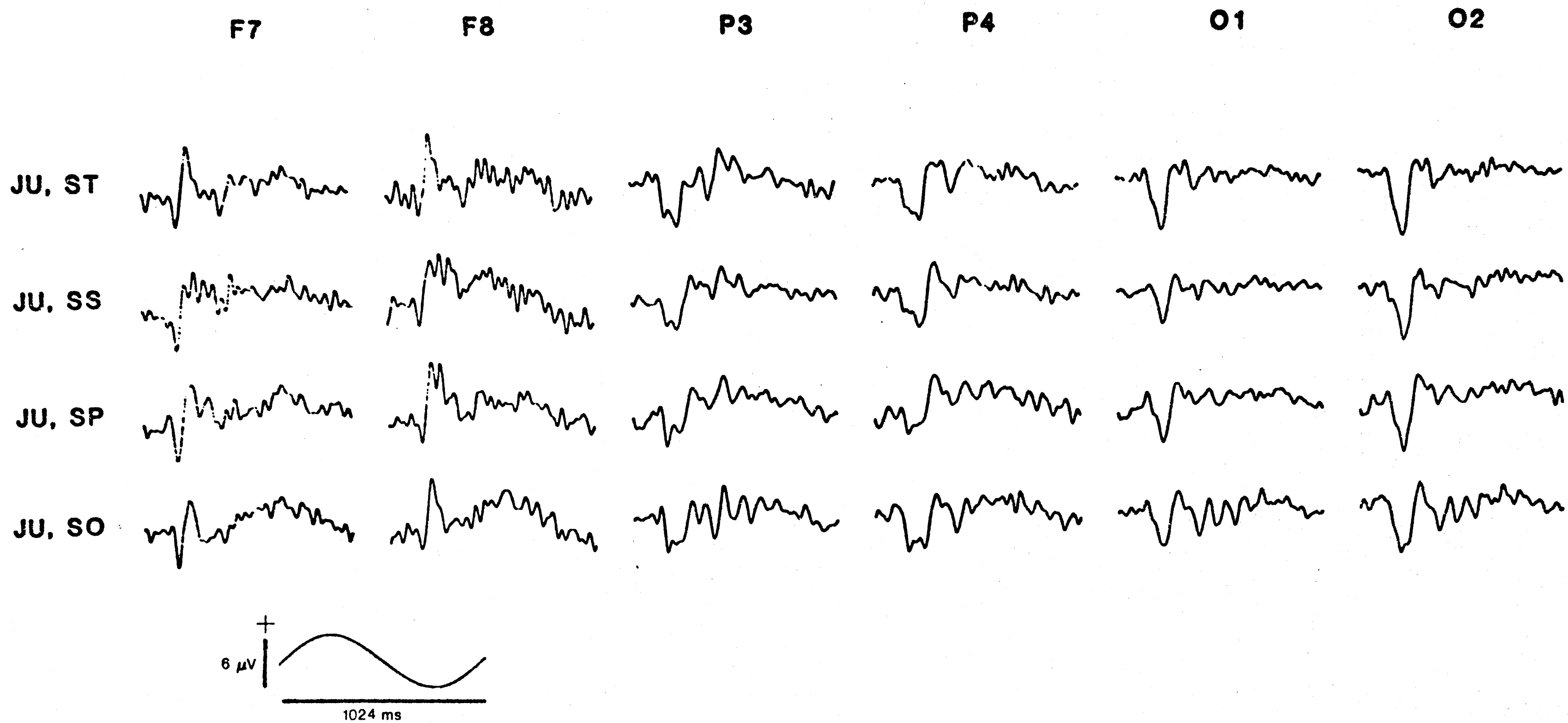

F7
F8
P3
P4
O1
O2
JU, ST
JU, SS
JU, SP
JU, SO
6 μV
1024 ms

Figure 23. Subject JU's $\overline{\Sigma 64}$ VERs Resulting from Large Geometrical Figures.

LT stands for Large Triangle; LS for Large Square; LP for Large Pentagon; and LO for Large Circle. Electrode positions F_7, F_8, P_3, P_4, O_1, and O_2 are shown across the top of the figure.

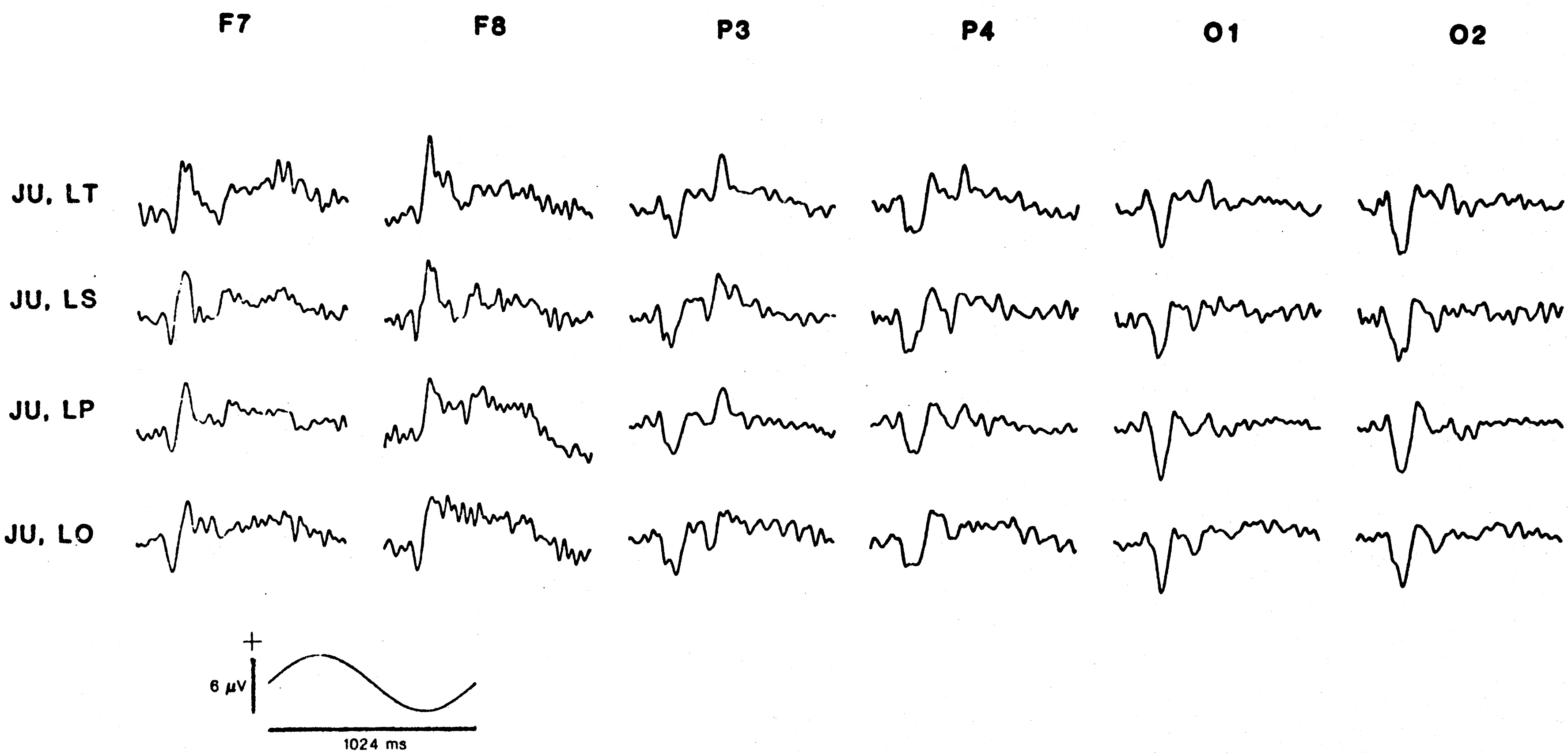
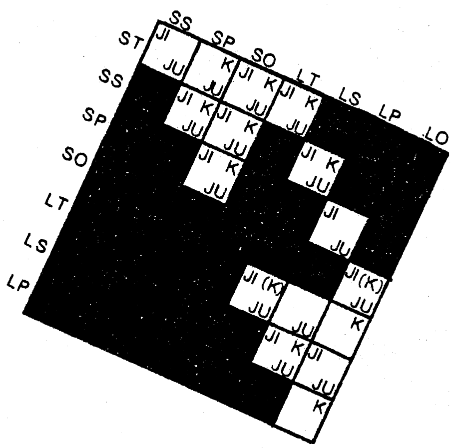

F7
F8
P3
P4
O1
O2
JU, LT
JU, LS
JU, LP
JU, LO
+
6 μV
1024 ms

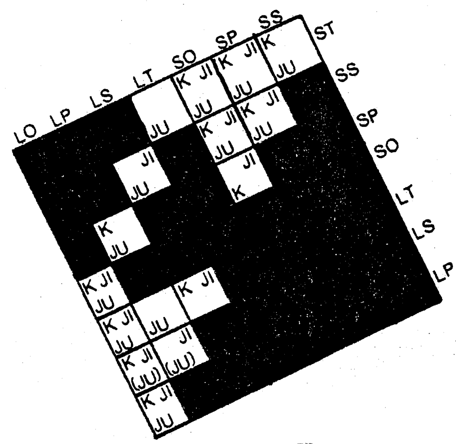
Figure 24. Binary Arrays Based on the Geometrical Figure Comparisons in Appendix D.

Each comparison is defined by the intersection of a row and a column. Each matrix represents comparisons at a specific electrode site (clockwise from the upper left: F_7, F_8, P_4, O_2, O_1, and P_3). A subject symbol (K, JI, JU) in the array indicates a difference in associated VER waveforms. Entrance into the array is based on at least one amplitude difference of a frequency component being greater than that of both replications by 0.1 x (error associated with that frequency component). Circled subject symbols indicate a particularly great difference (> 0.5 μV or > 4 frequency components having an amplitude difference above criterion).
Stimulus symbols are:

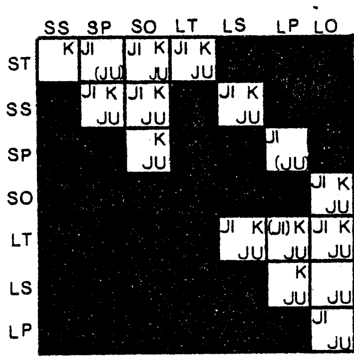
ST = Small Triangle	LT = Large Triangle
SS = Small Square	LS = Large Square
SP = Small Pentagon	LP = Large Pentagon
SO = Small Circle	LO = Large Circle



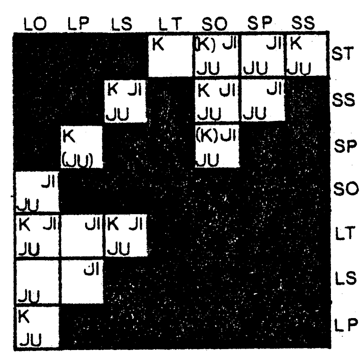
F7



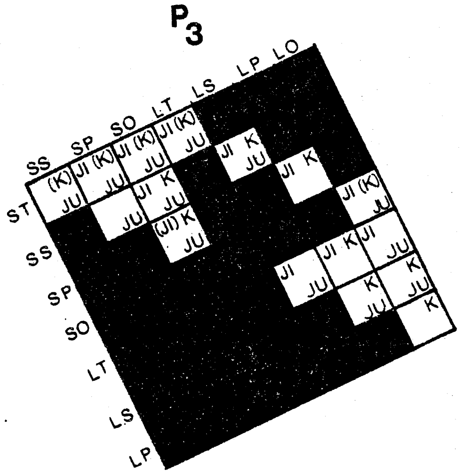
F8



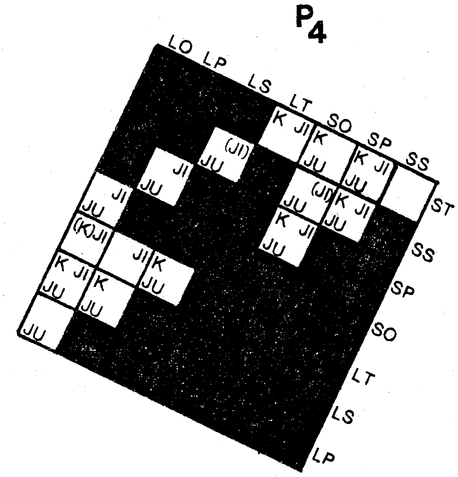
P3



P4



O1



O2

subject JU showed a difference between the Large Square (LS) and Large Circle (LO) with respect to parietal electrodes P_3 and P_4. Only subject K showed a difference between the Large Triangle (LT) and the Large Circle at F_7.

Large and small geometrical figure comparisons between figures with horizontal and vertical lines and figures with oblique lines gave exactly opposite results. With respect to the small figures, the Small Square (SS) - Small Pentagon (SP) comparison showed a greater overall difference than the Small Triangle (ST) - Small Square comparison. With respect to the large geometrical figures, the Large Triangle (LT) - Large Square (LS) comparison gave a greater overall difference than the Large Triangle - Large Pentagon (LP) comparison. Of all the small geometrical figure comparisons, the ST - SS comparison gave the least overall difference (Table 1A). Of all the large geometrical figure comparisons, the LT - LS comparison gave the greatest overall difference (Table 1B).

Differences between the same geometrical forms of different angular subtense also showed differences for most subjects at all electrode positions. However, once again there were differences among the subjects. For example, all three subjects showed differences between the Small and Large triangles (ST and LT respectively) at electrode sites F_7, P_3 and O_1 (left hemisphere). At electrode sites F_8 and P_4 only subject K showed a difference. At electrode site O_2 subjects JI and K showed a difference, but not subject JU.

Table 1. Geometrical Figure Comparisons Ranked by Overall Difference.

Entrance into the table is based on at least one amplitude difference of a frequency component being greater than that of both replications by 0.1 x (error associated with that frequency component). The order of comparisons is based on the sum of the number of subjects showing a difference at all electrode positions.

Table A gives the ranking of comparisons from most to least overall difference for the small geometrical figures.

Table B gives the ranking of comparisons from most to least overall difference for the large geometrical figures.

Table C ranks comparisons of geometrical figures with small versus large angular subtense, but with the same form.

Electrode positions F_7, F_8, P_3, P_4, O_1, and O_2 label each column except the last, which gives the sum of the number of subjects across all electrode sites showing a difference for each particular comparison.

Geometrical figure symbols are:

ST = Small Triangle	LT = Large Triangle
SS = Small Square	LS = Large Square
SP = Small Pentagon	LP = Large Pentagon
SO = Small Circle	LO = Large Circle

TABLE 1

A

	F_7	F_8	P_3	P_4	O_1	O_2	TOTAL
ST vs SO	3	3	3	3	3	2	17
SS vs SO	3	3	3	3	3	2	17
SP vs SO	3	2	2	3	3	3	16
ST vs SP	2	3	2	2	3	3	15
SS vs SP	3	3	3	2	1	3	15
ST vs SS	2	2	1	2	2	0	9
TOTAL	16	16	14	15	15	13	

B

	F_7	F_8	P_3	P_4	O_1	O_2	TOTAL
LT vs LS	3	2	3	3	2	2	15
LT vs LO	1	3	3	3	2	2	14
LS vs LO	2	3	1	1	3	3	13
LS vs LP	3	2	2	1	3	2	13
LP vs LO	1	3	2	2	1	1	10
LT vs LP	1	1	3	1	2	1	9
TOTAL	11	14	14	11	13	11	

C

	F_7	F_8	P_3	P_4	O_1	O_3	TOTAL
SO vs LO	3	3	3	2	3	2	16
SS vs LS	3	2	3	3	3	2	16
ST vs LT	3	1	3	1	3	2	13
SP vs LP	2	2	2	2	2	2	12
TOTAL	11	8	11	8	11	8	

C. Trigram Comparisons

Differences were generally found between $\overline{\Sigma 64}$ VERs obtained from different trigrams. This was true of all electrode sites and for all subjects. However, two exceptions are notable; the comparison between RAW and RWA at electrode site P_3 and between RAW and AWR at electrode site O_2. Only subject K's VERs showed differences (Figure 29; Table 2). The greatest overall differences are clearly between WAR and the other trigrams (first, second and third rows of Table 2). There is no apparent ordering associated with meaningful versus nonsense trigrams. The RAW versus RWA comparison gave the least overall differences while the WAR versus AWR gave the greatest. A replication of these data with one subject using four different trigrams (ART, RAT, ATR and RTA) confirmed that there was no systematic pattern of difference between meaningful and nonsense trigrams (Figure 28, Appendix E). See Figures 25 through 28 for trigram $\overline{\Sigma 64}$ VERs.

D. Reversible Figure Comparisons

Figures 30 and 31 show VERs resulting from the "toward" interpretation of the Reversible Wedge. Each $\overline{\Sigma 32}$ VER is the summed and averaged data for a particular stimulus derived from four sessions (with eight presentations from each session). Alternate sessions were chosen for each $\overline{\Sigma 32}$ average. Each subject's $\overline{\Sigma 32}$ VER is based on sixteen left hand responses and sixteen right hand responses. Each $\overline{\Sigma 32}$ VER was digitally filtered after summing and averaging. Superimposed records shown in the two figures are digitally filtered

Figure 25. Subject K's Trigram $\overline{\Sigma 64}$ VERs.

Electrode positions F_7, F_8, P_3, P_4, O_1, and O_2 label the columns of VERs. The subject symbol followed by the stimulus labels each row: K, WAR; K, RAW; K, AWR, and K RWA.

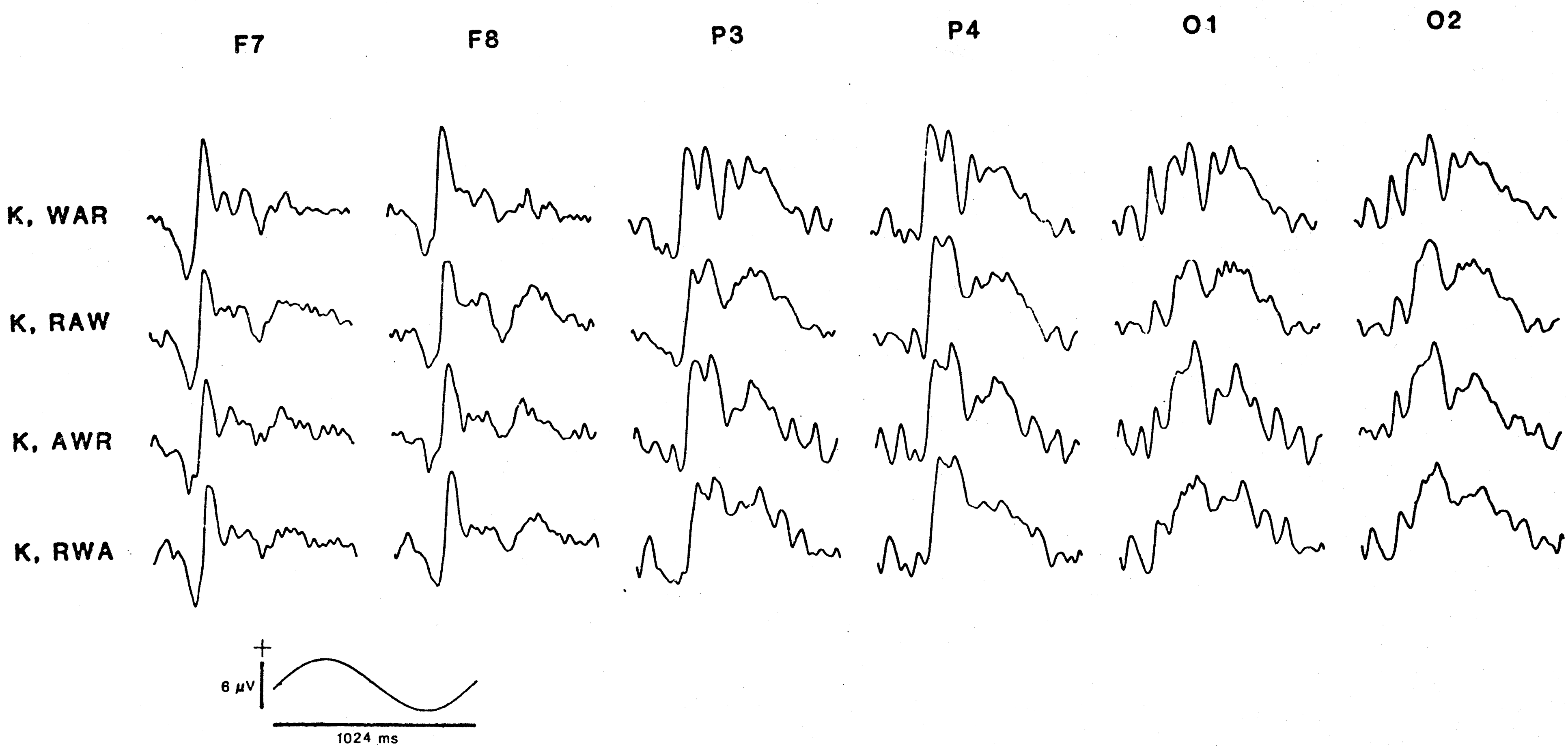

F7
F8
P3
P4
O1
O2
K, WAR
K, RAW
K, AWR
K, RWA
+
6 μV
1024 ms

Figure 26. Subject JI's Trigram $\overline{\Sigma 64}$ VERs.

Electrode positions F_7, F_8, P_3, P_4, O_1, and O_2 label the columns of VERs. The subject symbol followed by the stimulus labels each row: JI, WAR; JI, RAW; JI, AWR; and JI, RWA.

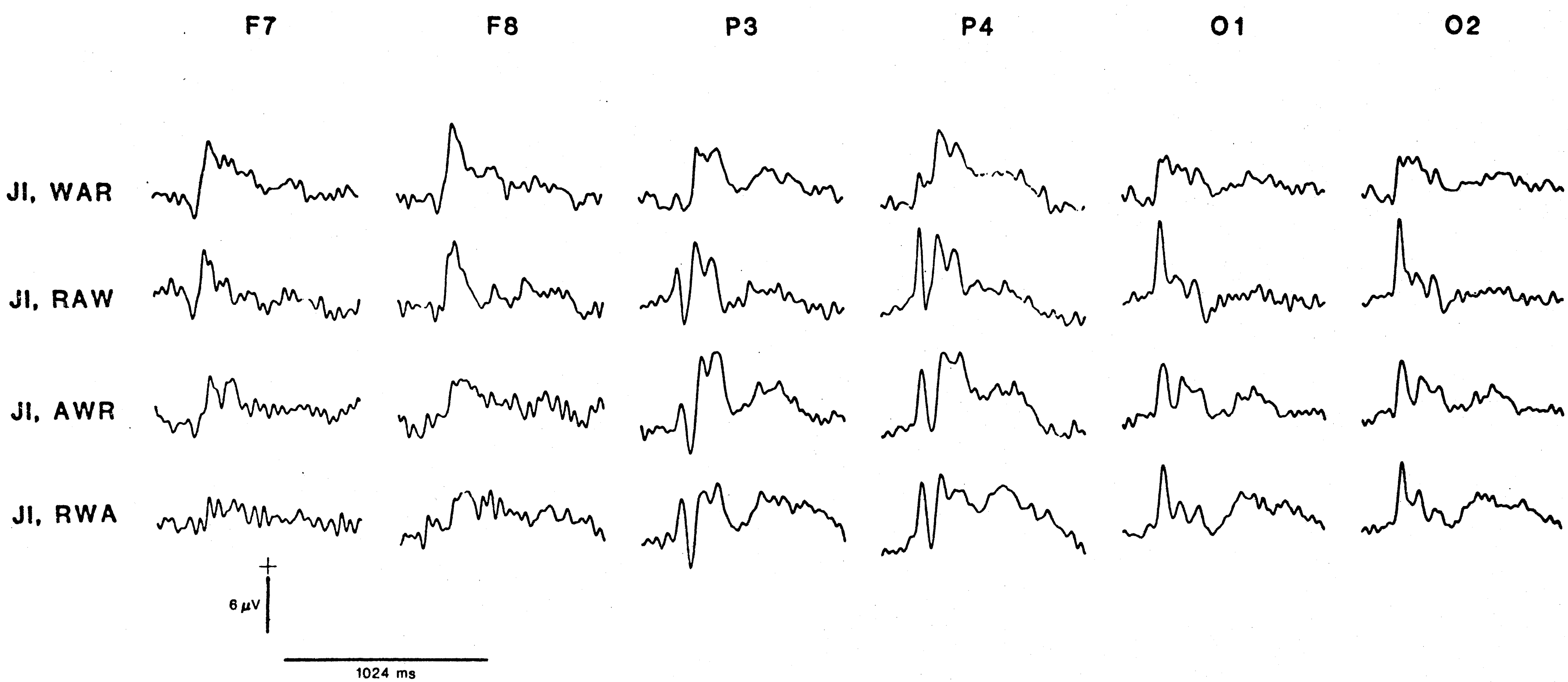

F7
F8
P3
P4
O1
O2
JI, WAR
JI, RAW
JI, AWR
JI, RWA
+
6 µV
1024 ms

Figure 27. Subject JU's Trigram $\overline{\Sigma 64}$ VERs.

Electrode positions F_7, F_8, P_3, P_4, O_1, and O_2 label the columns of VERs. The subject symbol followed by the stimulus labels each row: JU, WAR; JU, RAW; JU, AWR; and JU, RWA.

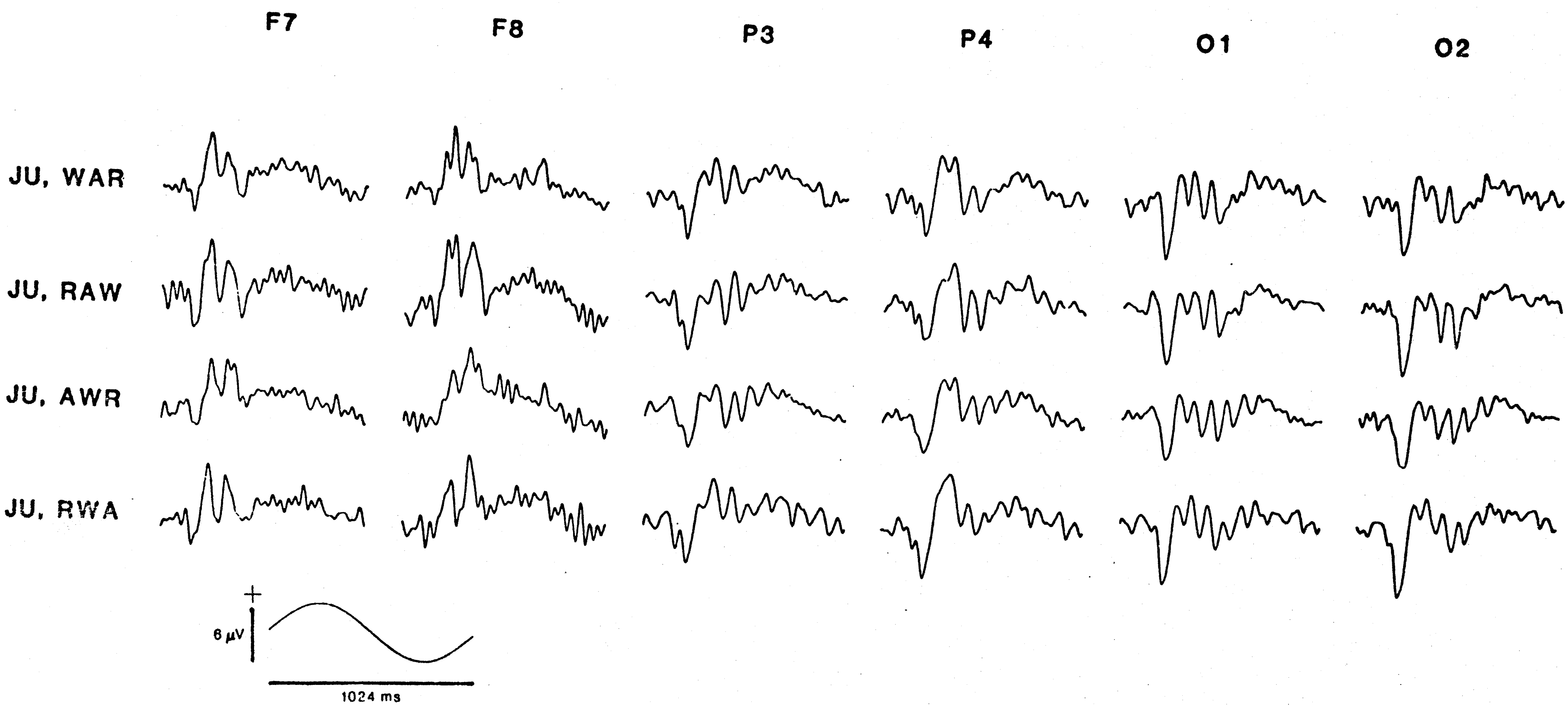

F7
F8
P3
P4
O1
O2
JU, WAR
JU, RAW
JU, AWR
JU, RWA
+
6 µV
1024 ms

Figure 28. Subject JU's $\overline{\Sigma 64}$ VERs from a Second Set of Trigrams.

Electrode positions F_7, F_8, P_3, P_4, O_1, and O_2 label columns of VERs. The subject symbol followed by the stimulus labels each row: JU, ART; JU, RAT; JU, ATR; and JU, RTA.

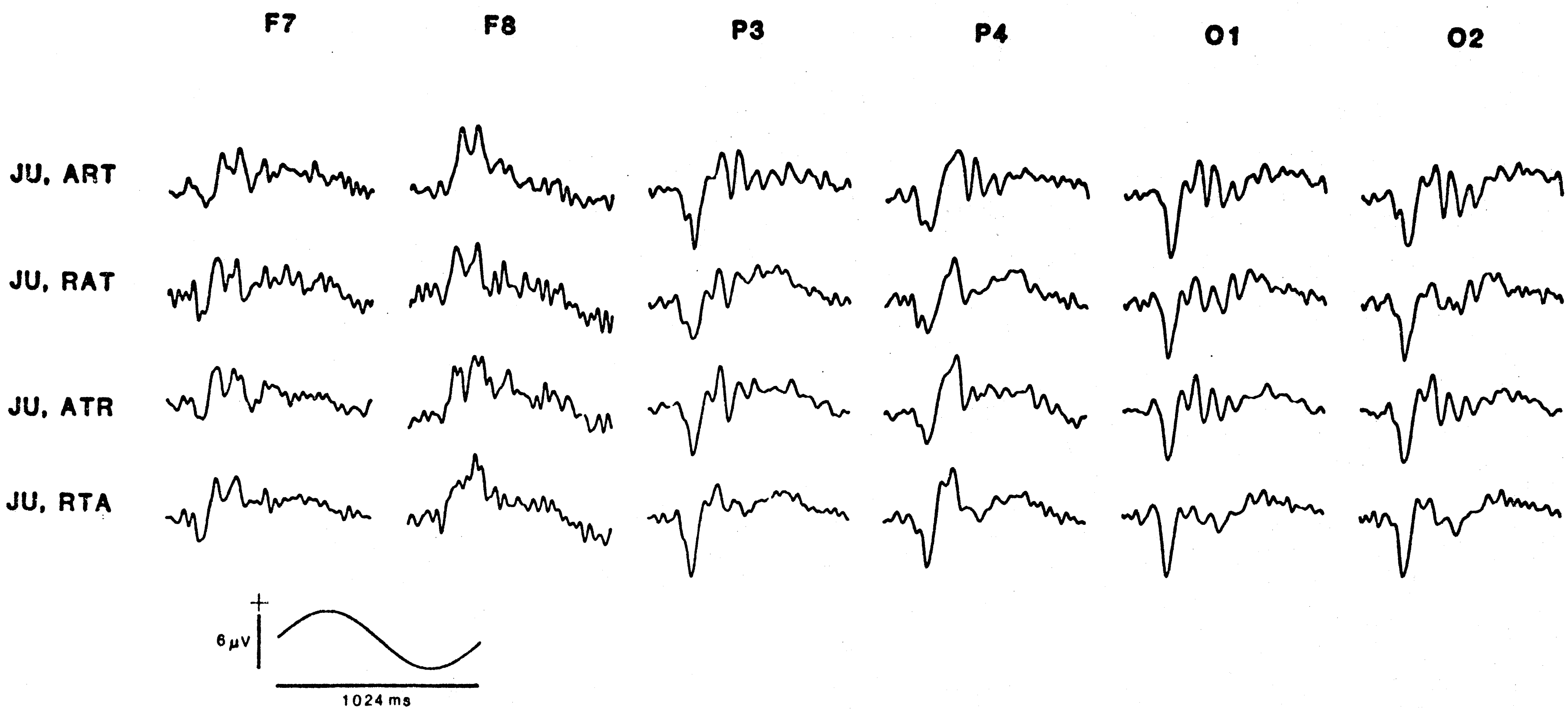
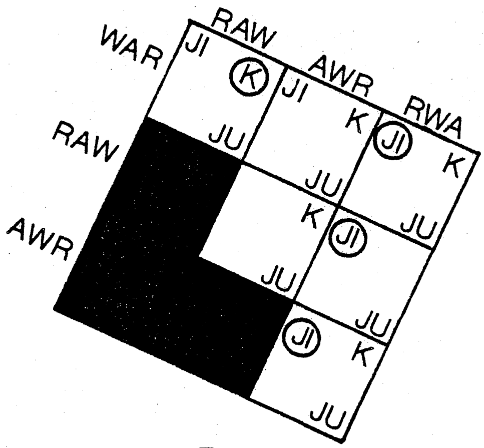
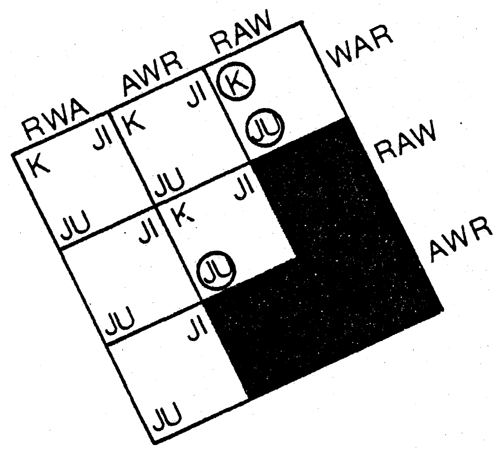

F7
F8
P3
P4
O1
O2
JU, ART
JU, RAT
JU, ATR
JU, RTA
+
6 μV
1024 ms

Figure 29. Binary Arrays Based on the Trigram Comparisons in Appendix E.

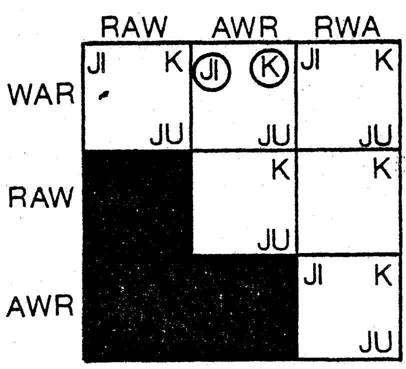
Each comparison is defined by the intersection of a row and a column. Each matrix represents comparisons at a specific electrode site (clockwise from the upper left: F_7, F_8, P_4, O_2, O_1 and P_3). A subject symbol (K, JI, JU) in the array indicates a difference in associated VER waveforms. Entrance into the array is based on at least one amplitude difference of a frequency component being greater than that of both replications by 0.1 x (error associated with that frequency component). Circled subject symbols indicate a particularly great difference ($>$ 0.5 μV or $>$ 4 frequency components having an amplitude difference above criterion). The trigrams compared are: WAR, RAW, AWR, and RWA.



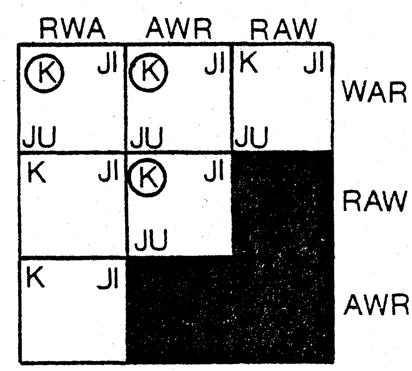
F_7



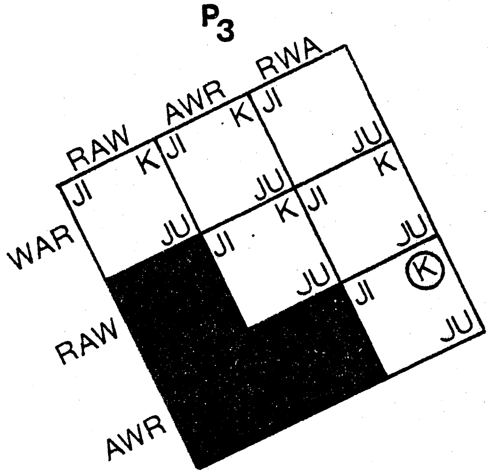
F_8



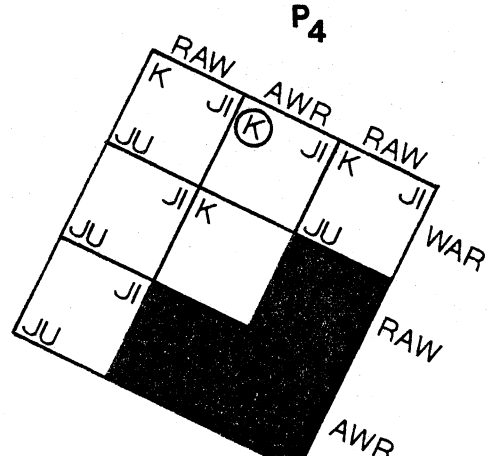
P_3



P_4



O_1



O_2

Table 2. Trigram Comparisons Ranked by Overall Difference.

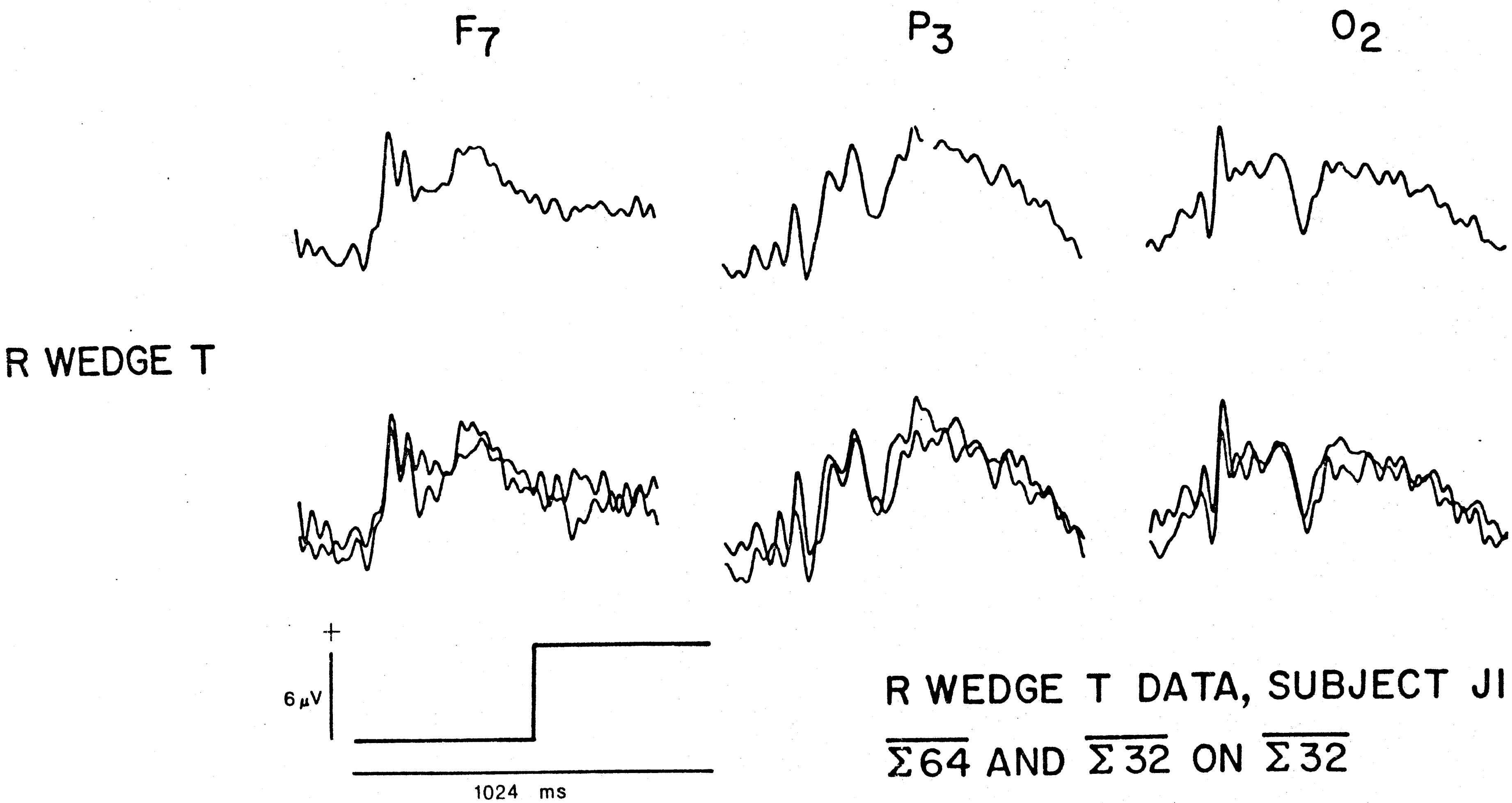
Entrance into the table is based on at least one amplitude difference of a frequency component being greater than that of both replications by 0.1 x (error associated with that frequency component). The rank-order of comparisons is based on the sum of the total number of subjects showing a difference at all electrode positions. The ranking is from most to least overall difference. Electrode positions F_7, F_8, P_3, P_4, O_1, and O_2 label each column except the last, which gives the sum of the number of subjects across electrode sites giving a difference for each particular comparison.

TABLE 2

	F_7	F_8	P_3	P_4	O_1	O_2	TOTAL
WAR vs AWR	3	3	3	3	3	2	17
WAR vs RAW	3	2	3	3	3	3	17
WAR vs RWA	3	3	3	3	2	3	17
AWR vs RWA	3	2	3	2	3	2	15
RAW vs AWR	2	3	2	3	3	1	14
RAW vs RWA	2	2	1	2	3	2	12
TOTAL	16	15	15	16	17	13	

Figure 30. Subject JI's Superimposed $\overline{\Sigma 32}$ "Reversible Wedge Toward" (R Wedge T) VERs and Their Means ($\Sigma 64$ VERs).

Reversible figure VERs were obtained during 8 recording sessions (8 records/session). Each $\overline{\Sigma 32}$ VER (row 2) is the digitally filtered mean of $\overline{\Sigma 32}$ records combined from 4 alternate sessions. 16 of the 32 records in each $\overline{\Sigma 32}$ VER were obtained when the subject responded to stimuli using his left hand; 16 when the subject used his right hand. Each row 1 VER is the mean of the two $\overline{\Sigma 32}$ VERs just below it. Data from 3 electrode positions is shown: F_7, P_3, and O_2. Superimposed $\overline{\Sigma 32}$ VERs show the error inherent in these data.

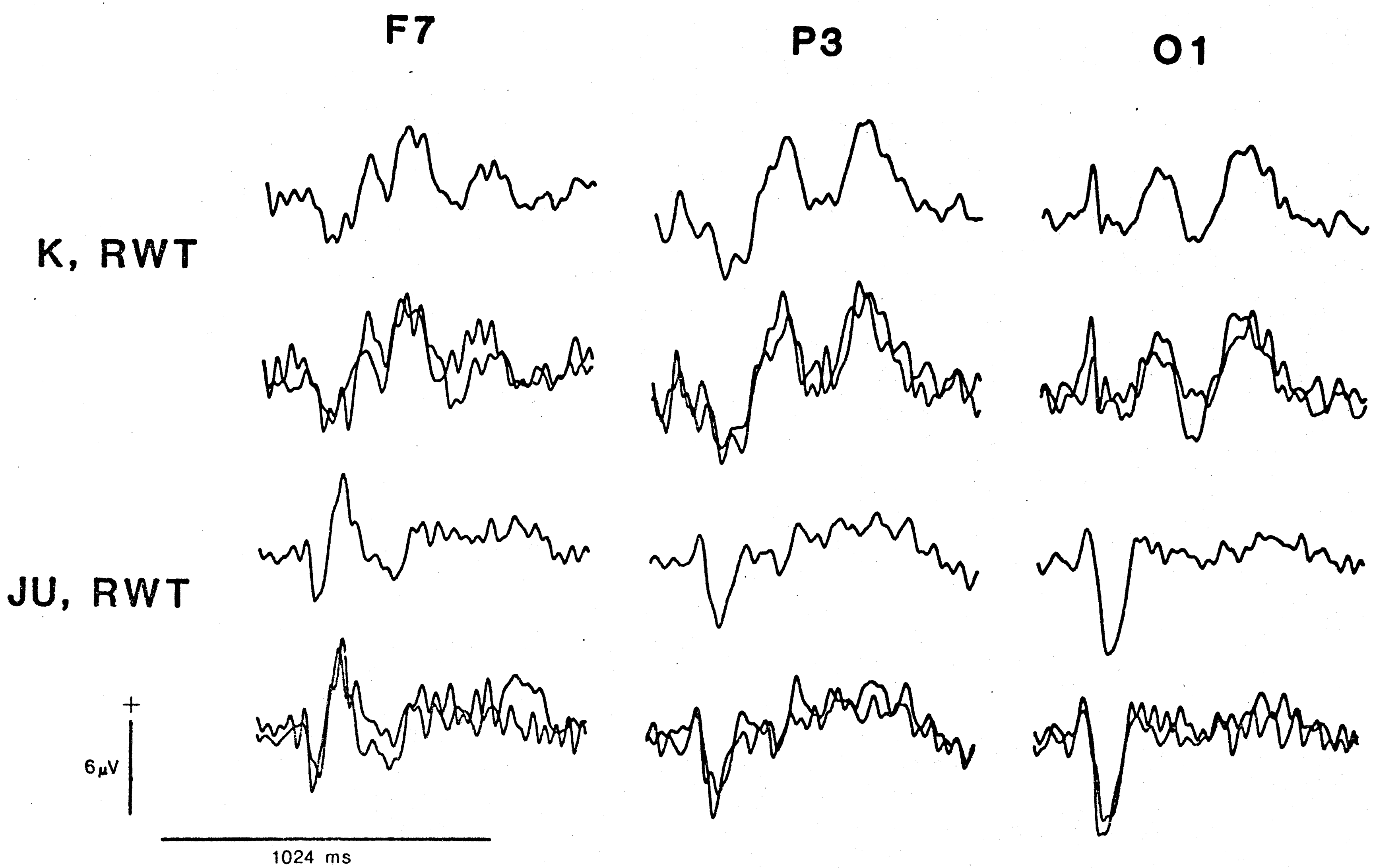


R WEDGE T DATA, SUBJECT JI

$\overline{\Sigma 64}$ AND $\overline{\Sigma 32}$ ON $\overline{\Sigma 32}$

Figure 31. Superimposed $\overline{\Sigma 32}$ "Reversible Wedge Toward" (RWT) VERs and Their Means, $\overline{\Sigma 64}$ VERs (Subjects K and JU).

Reversible figure VERs were obtained during 8 recording sessions (8 records/session). Each $\overline{\Sigma 32}$ VER (rows 2 and 4) is the digitally filtered mean of 32 records combined from 4 alternate sessions. 16 of the 32 records in each $\overline{\Sigma 32}$ VER were obtained when the subject responded to stimuli using his left hand; 16 when the subject used his right hand. Each VER in rows 1 and 3 is the mean of the two $\overline{\Sigma 32}$ VERs just below it. Rows 1 and 2 show "Reversible Wedge Toward" VERs from subject K (K, RWT); rows 3 and 4 "Reversible Wedge Toward" VERs from subject JU (JU, RWT). Data from 3 electrode positions is shown: F_7, P_3, and O_1. Superimposed $\overline{\Sigma 32}$ VERs show the error inherent in these data.


F7
P3
O1
K, RWT
JU, RWT
+
6µV
1024 ms

$\overline{\Sigma 32}$ VERs. Each VER shown above the superimposed record is the mean of the two ($\overline{\Sigma 64}$).

Figure 32 provides a comparison of $\overline{\Sigma 64}$ VER records from each subject at each electrode site. VERs from a particular subject at a given electrode site are very stereotyped, while VERs across subjects show marked differences. These differences across subjects are consistent across stimuli for every subject (Figures 33, 34 and 35).

A binary array based on Appendix F data is given in Figure 36. Table 3 summarizes these results, ordering comparisons with respect to overall differences. The same criterion for entrance into the binary array is used here as previously. Support for using the same criterion as with previous data is given in Appendix B, where the error for reversible figure data coincides closely with that from the geometrical figures, trigrams, etc.

The comparison giving the greatest overall difference was between the "Solid Wedge Toward" (SWT) and the "Solid Wedge Away" (SWA). The overall differences between the solid wedges and the reversible wedge interpreted as having the same orientation were intermediate. The overall differences between the two interpretations of the reversible figures were the smallest (Table 3).

Patterns of difference with respect to electrode site tend to be idiosyncratic. For example, subject JI showed no differences between interpretations of the reversible wedge at electrode sites F_7 and F_8, but subject JU did. At electrode sites P_3 and P_4,

Figure 32. Comparison of $\overline{\Sigma 64}$ "Reversible Wedge Toward" (R Wedge T) VERs from Subjects K, JU and JI.

These reversible figure VERs were obtained during 8 recording sessions (8 records/session). 32 of the 64 records in each $\overline{\Sigma 64}$ VER were obtained when the subject used his left hand; 32 when the subject used his right hand. Electrode positions label each column (F_7, F_8, P_3, P_4, O_1 and O_2). VERs from each subject are characteristic. Differences in the general form of VERs across both subjects and electrode sites hold across stimuli (Figures 33, 34 and 35).

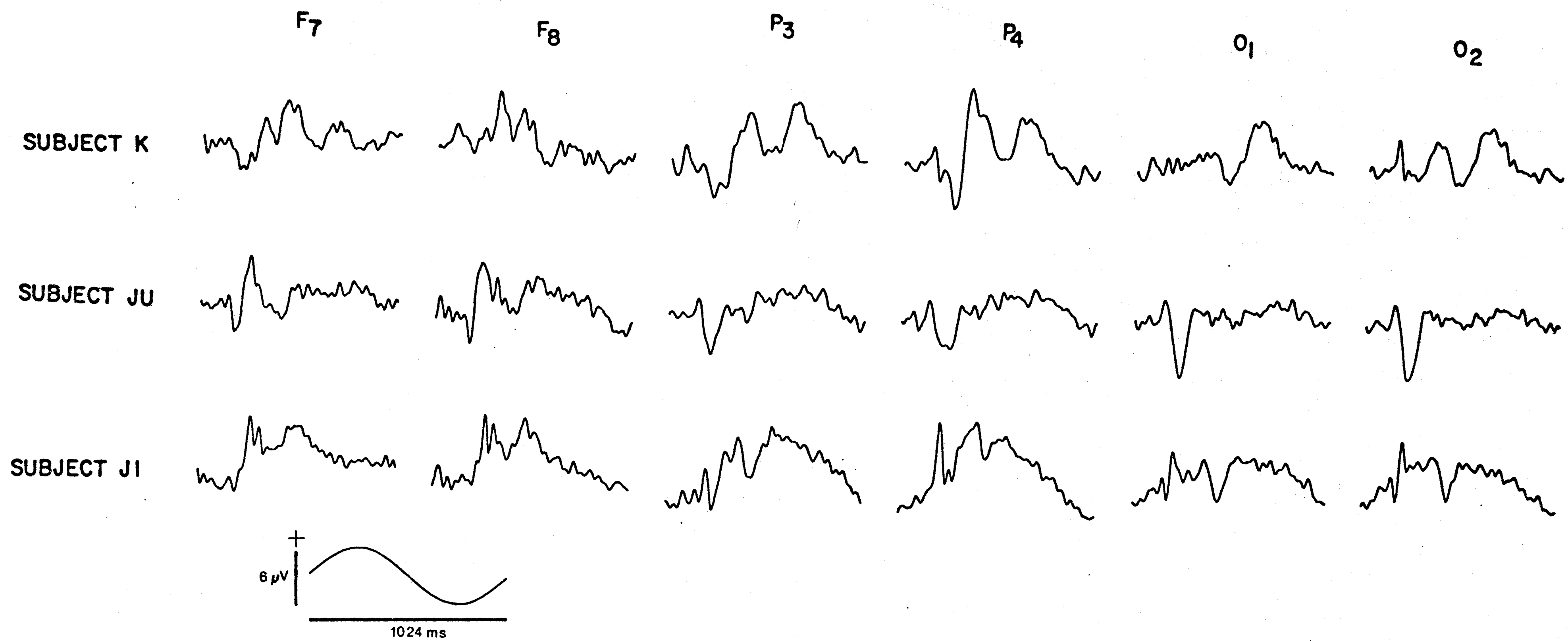

F7
F8
P3
P4
O1
O2
SUBJECT K
SUBJECT JU
SUBJECT JI
+
6 μV
1024 ms

Figure 33. Subject K's $\overline{\Sigma 64}$ VERs Resulting from Solid and Reversible Figures.

Each VER is the mean of 64 records obtained during 8 recording sessions (8 records/session). 32 of the records contributing to each mean were obtained when the subject responded to stimuli using his left hand; 32 when the subject used his right hand. Stimulus symbols labeling each row are: Solid wedge oriented toward the subject (S Wedge T); solid wedge oriented away from the subject (S Wedge A); reversible wedge interpreted as oriented toward the subject (R Wedge T); reversible wedge interpreted as oriented away from the subject (R Wedge A); reversible staircase interpreted as viewed from the top (Stairs Top); reversible staircase interpreted as viewed from the bottom (Stairs Bottom). Electrode positions F_7, F_8, P_3, P_4, O_1 and O_2 label each column.

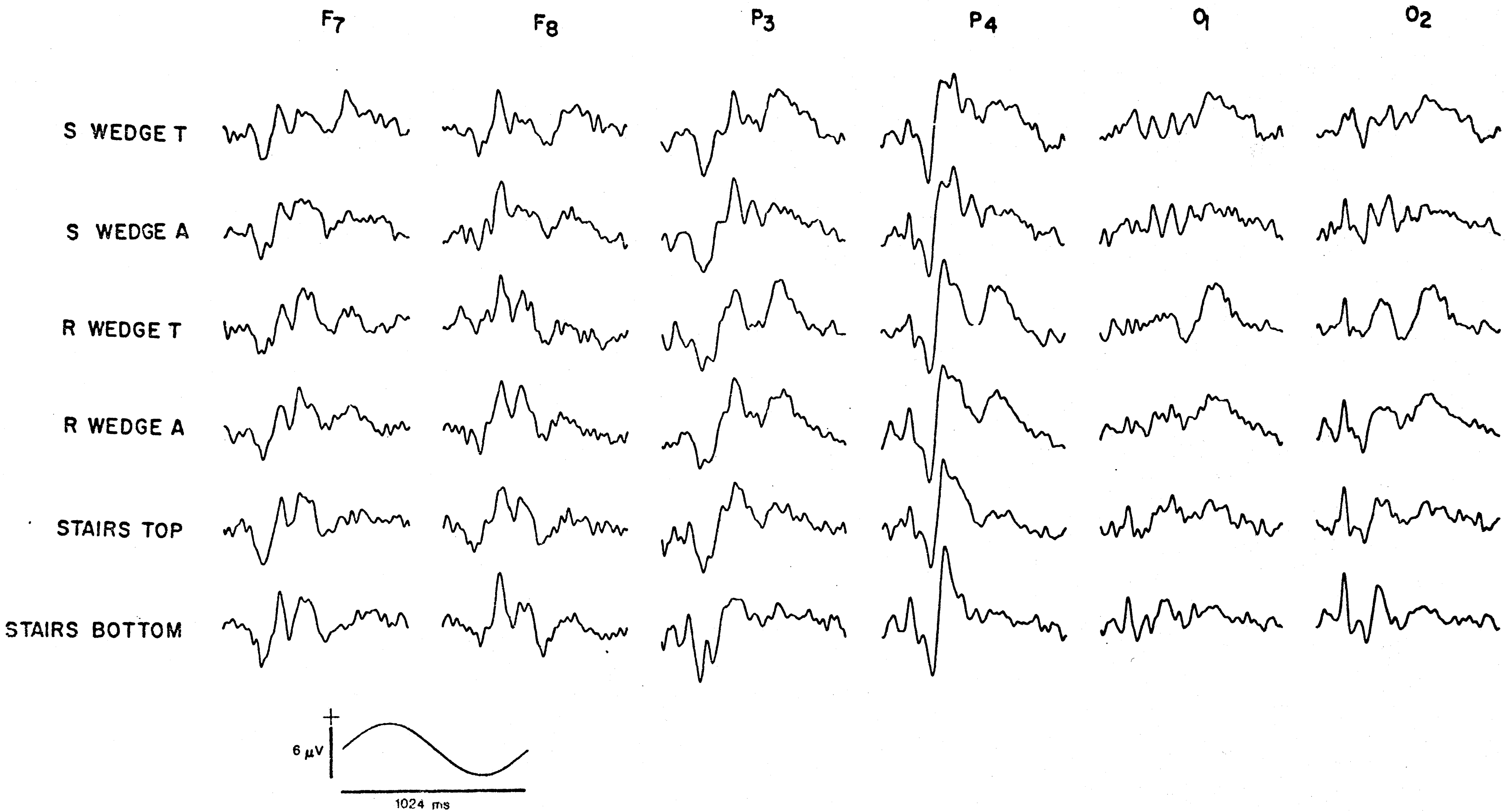
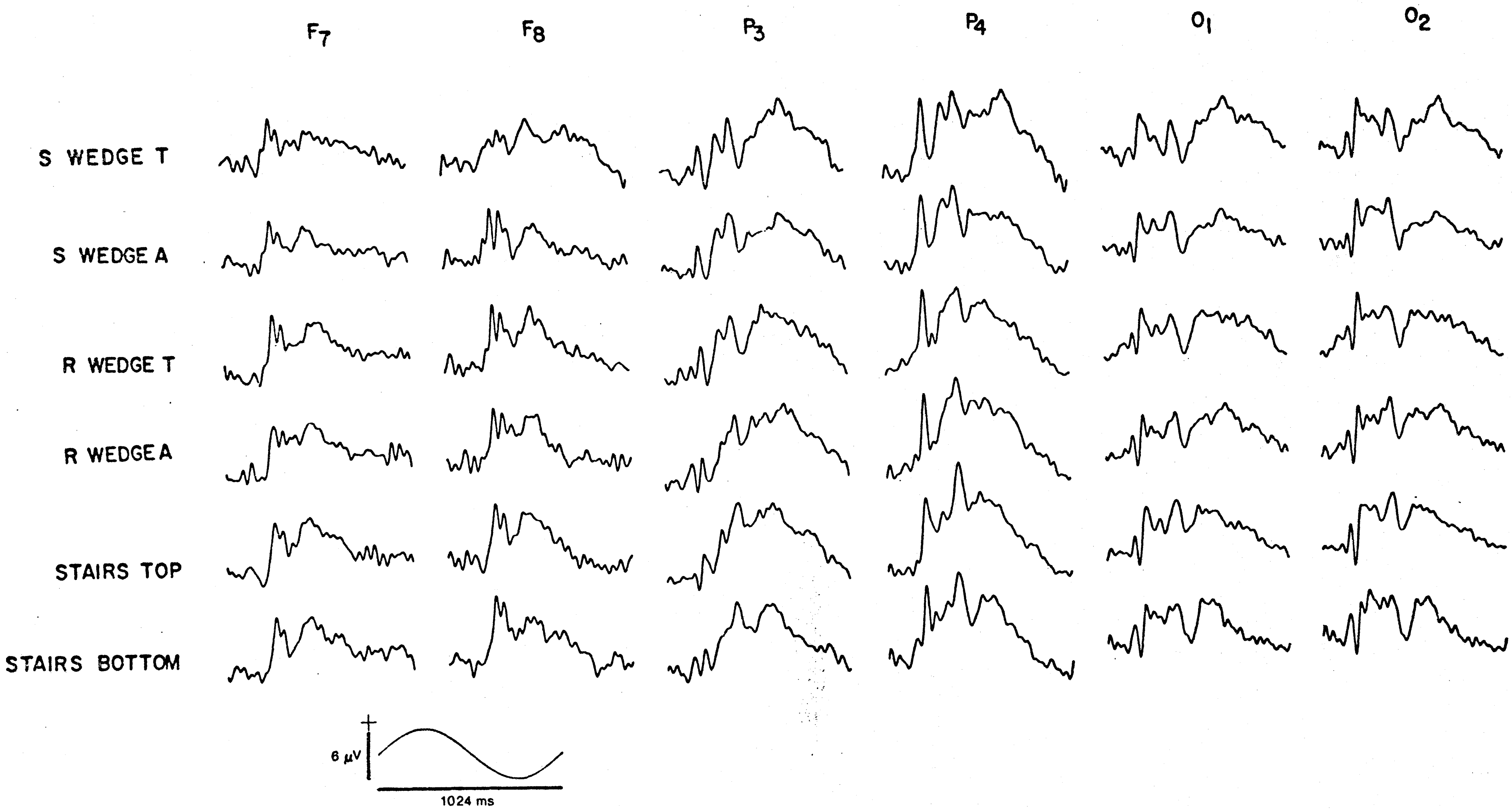

F7
F8
P3
P4
O1
O2
S WEDGE T
S WEDGE A
R WEDGE T
R WEDGE A
STAIRS TOP
STAIRS BOTTOM
+
6 μV
1024 ms

Figure 34. Subject JI's $\overline{\Sigma 64}$ VERs Resulting from Solid and Reversible Figures.

Each VER is the mean of 64 records obtained during 8 recording sessions (8 records/session). 32 of the records contributing to each mean were obtained when the subject responded to stimuli using his left hand; 32 when the subject used his right hand. Stimulus symbols labeling each row are: solid wedge oriented toward the subject (S Wedge T); solid wedge oriented away from the subject (S Wedge A); reversible wedge interpreted as oriented toward the subject (R Wedge T); reversible wedge interpreted as oriented away from the subject (R Wedge A); reversible staircase interpreted as viewed from the top (Stairs Top); reversible staircase interpreted as viewed from the bottom (Stairs Bottom). Electrode positions F_7, F_8, P_3, P_4, O_1 and O_2 label each column.



F7
F8
P3
P4
O1
O2
S WEDGE T
S WEDGE A
R WEDGE T
R WEDGE A
STAIRS TOP
STAIRS BOTTOM
+
6 μV
1024 ms

Figure 35. Subject JU's $\overline{\Sigma 64}$ VERs Resulting from Solid and Reversible Figures.

Each VER is the mean of 64 records obtained during 8 recording sessions (8 records/session). 32 of the records contributing to each mean were obtained when the subject responded to stimuli using her left hand; 32 when the subject used her right hand. Stimulus symbols labeling each row are: solid wedge oriented toward the subject (S Wedge T); solid wedge oriented away from the subject (S Wedge A); reversible wedge interpreted as oriented toward the subject (R Wedge T); reversible wedge interpreted as oriented away from the subject (R Wedge A); reversible staircase interpreted as viewed from the top (Stairs Top); reversible staircase interpreted as viewed from the bottom (Stairs Bottom). Electrode positions F_7, F_8, P_3, P_4, O_1 and O_2 label each column.

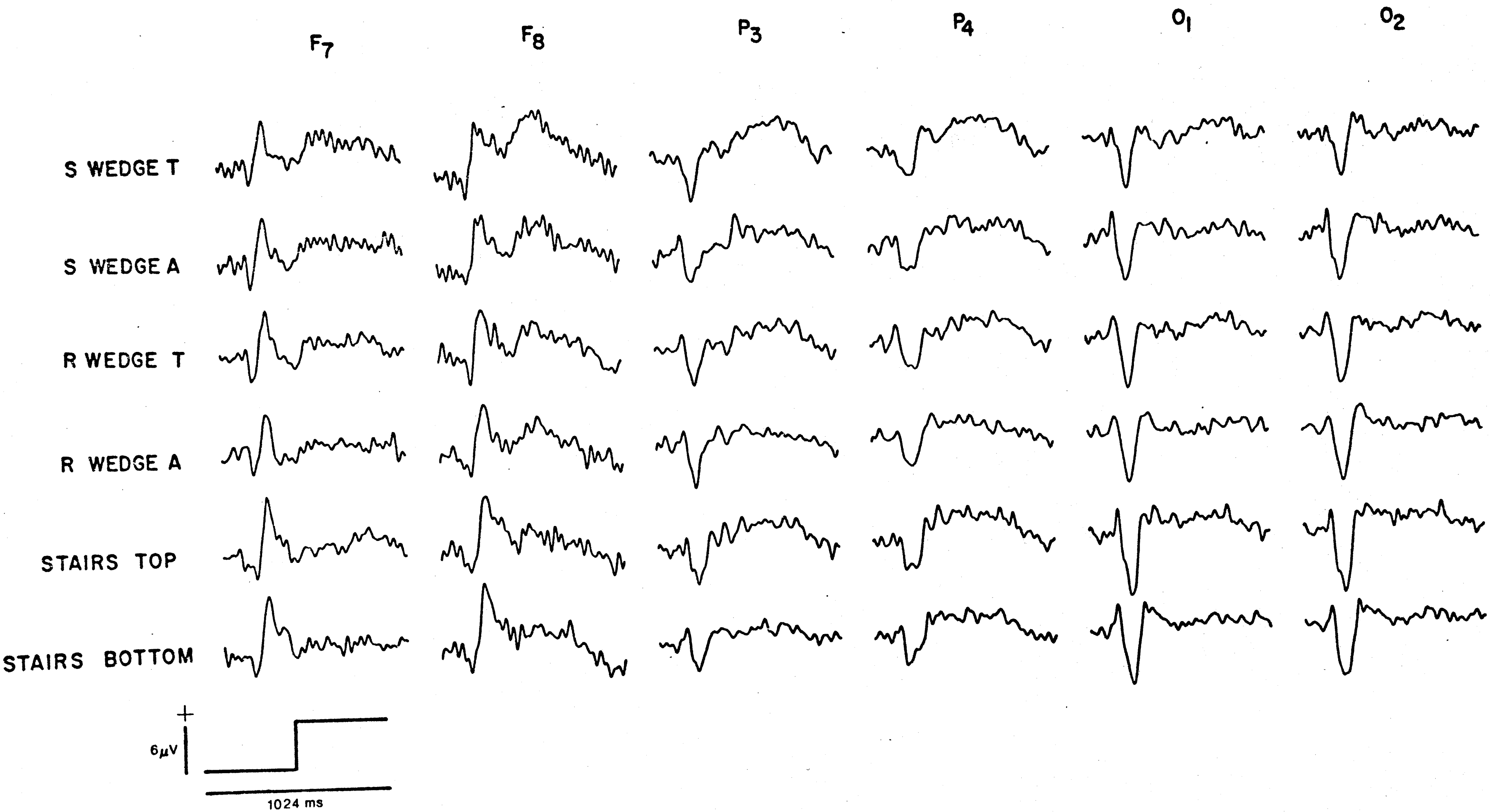

F7
F8
P3
P4
O1
O2
S WEDGE T
S WEDGE A
R WEDGE T
R WEDGE A
STAIRS TOP
STAIRS BOTTOM
+
6μV
1024 ms

Figure 36. Binary Array Based on the Reversible and Solid Figure Comparisons in Appendix F.

Each comparison is defined by the intersection of a row and a column. Each matrix represents comparisons at a specific electrode site (clockwise from the upper left: F_7, F_8, P_4, O_2, O_1 and P_3). A subject symbol (K, JI, JU) in the array indicates a difference in associated VER waveforms. Entrance into the array is based on at least one amplitude difference of a frequency component being greater than that of both replications by 0.1 x (error* associated with that frequency component). Circled subject symbols indicate a particularly great difference (> 0.5 μV or > 4 frequency components having an amplitude difference above criterion). Stimulus symbols are:

- SWT Solid wedge oriented toward the subject
- SWA Solid wedge oriented away from the subject
- RWT Reversible wedge interpreted as oriented toward the subject
- RWA Reversible wedge interpreted as oriented away from the subject
- SRSU Reversible staircase interpreted as viewed from the top (stairs right side up)
- SUSD Reversible staircase interpreted as viewed from the bottom (stairs upside down)

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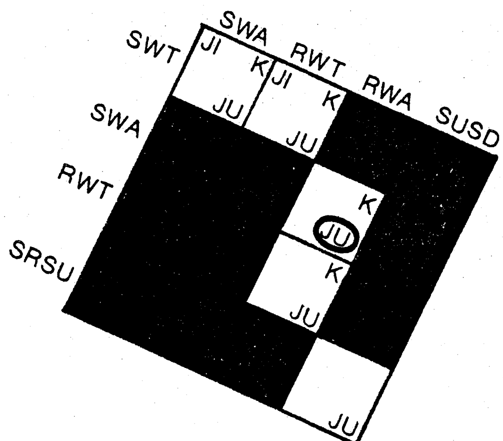
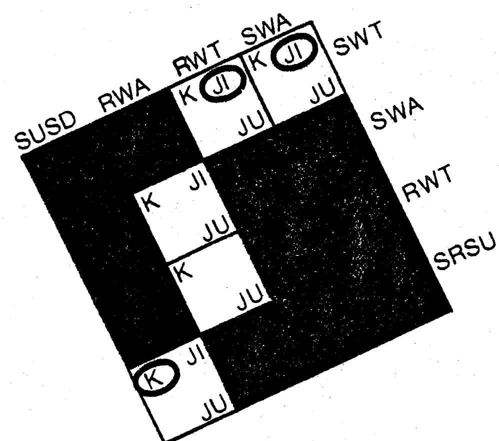
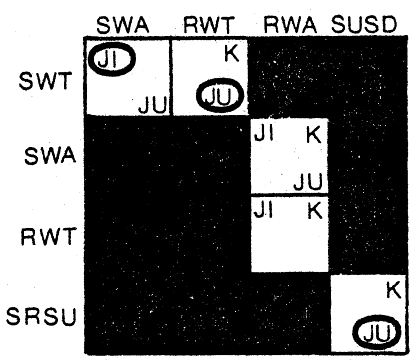
* Based on the mean of $\overline{\Sigma 32}$ VERs summed from alternate sessions that were digitally filtered.



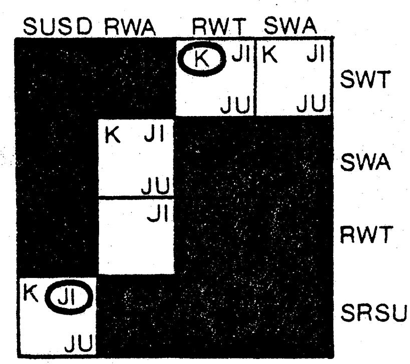
F7



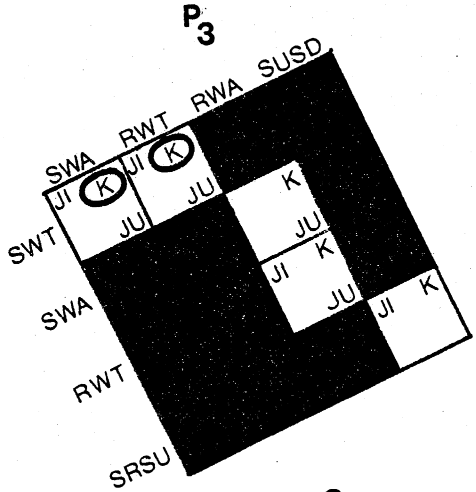
F8



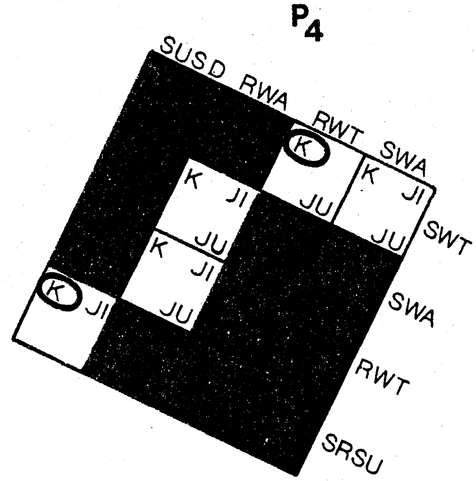
P3



P4



O1



O2

Table 3. Reversible and Solid Figure Comparisons Ranked by Overall Difference.

Entrance into the table is based on at least one amplitude difference of a frequency component being greater than that of both replications (mean of $\overline{\Sigma 32}$ VERs summed from alternate sessions) by 0.1 x (error associated with that frequency component). The rank order of comparisons is based on the sum of the total number of subjects showing a difference at all electrode positions. The ranking is from most to least overall difference. Electrode positions F_7, F_8, P_3, P_4, O_1 and O_2 label each column except the last, which gives the sum of the number of subjects across electrode sites giving a difference for each particular comparison. Stimulus symbols used in comparisons labeling each row are:

SWT Solid wedge oriented toward the subject

SWA Solid wedge oriented away from the subject

RWT Reversible wedge interpreted as oriented toward the subject

RWA Reversible wedge interpreted as oriented away from the subject

SRSU Reversible staircase interpreted as viewed from the top (stairs right side up)

SUSD Reversible staircase interpreted as viewed from the bottom (stairs upside down)

TABLE 3

	F_7	F_8	P_3	P_4	O_1	O_2	TOTAL
SWT vs SWA	3	3	2	3	3	3	17
SWT vs RWT	3	3	2	3	3	2	16
SRSU vs SUSD	1	3	2	3	2	2	13
RWT vs RWA	2	2	2	1	3	3	13
TOTAL	11	14	11	13	13	13	

subject JI did show a difference, but subject JU did not. Subject K showed a difference at F_7, F_8 and P_3, but not at P_4. All subjects showed a difference with respect to interpretation of the reversible wedge at O_1 and O_2 (Figure 36).

E. Class Comparisons

Digitally filtered $\overline{\Sigma 64}$ VERs within each of four stimulus classes were summed and averaged to produce composite VERs. Data of this type, used for class comparisons, must be viewed with some caution. Individual VERs from different stimuli within a class can combine to mask particular components, or a single stimulus VER within a class can have an unusual component that shows up in the composite that makes the composite unrepresentative of the class. Every effort was made to avoid these problems by describing only composite VER components represented in the individual VERs making them up. None the less, generalizations drawn from comparisons of the time-voltage relationships of these composite VER components should be considered tentative.

Each geometrical figure (GF) composite VER is the average of six digitally filtered $\overline{\Sigma 64}$ VERs; from the small and large traingles, the small and large squares, and the small and large pentagons (Figures 37 and 39). Each reversible figure (RF) composite VER is also the average of 6 digitally filtered $\overline{\Sigma 64}$ VERs; from the solid wedges away and toward, the reversible wedges away and toward, and the right side up and upside down staircases (Figures 37 and 39). Each meaningful and nonsense trigram (MT and NT respectively) composite VER is the average of four digitally filtered $\overline{\Sigma 64}$ VERs. The MT composite VERs for subjects JU and K resulted from WAR, RAW, ART and RAT, while for subject JI they resulted from WAR, RAW, PIT and TIP. The NT composite VERs for subjects JU and K resulted from

Figure 37. Geometrical Figure, Meaningful Trigram, and Reversible Figure Composite VERs from Subjects K and JI.

Each geometrical figure composite VER (K, GF and JI, GF) is the sum and average of six geometrical figure $\overline{\Sigma 64}$ VERs: from the small and large triangles, from the small and large squares, and from the small and large pentagons. Subject K's meaningful trigram composite VERs (K, MT) are the sum and average of four meaningful trigram $\overline{\Sigma 64}$ VERs: from WAR, RAW, ART and RAT. Subject JI's meaningful trigram composite VERs (JI, MT) are also the sum and average of four meaningful trigram $\overline{\Sigma 64}$ VERs: from WAR, RAW, PIT and TIP. Both subject K's and subject JI's reversible figure VERs (K, RF and JI, RF respectively) are the sum and average of four reversible figure interpretation $\overline{\Sigma 64}$ VERs and two solid figure $\overline{\Sigma 64}$ VERs: reversible wedge toward, reversible wedge away, stairs right side up, stairs upside down, solid wedge toward and solid wedge away. The vertical lines are at 100 ms intervals beginning with each record's onset. Electrode positions label each column of composite VERs: from left to right F_7, F_8, P_3, P_4, O_1 and O_2.

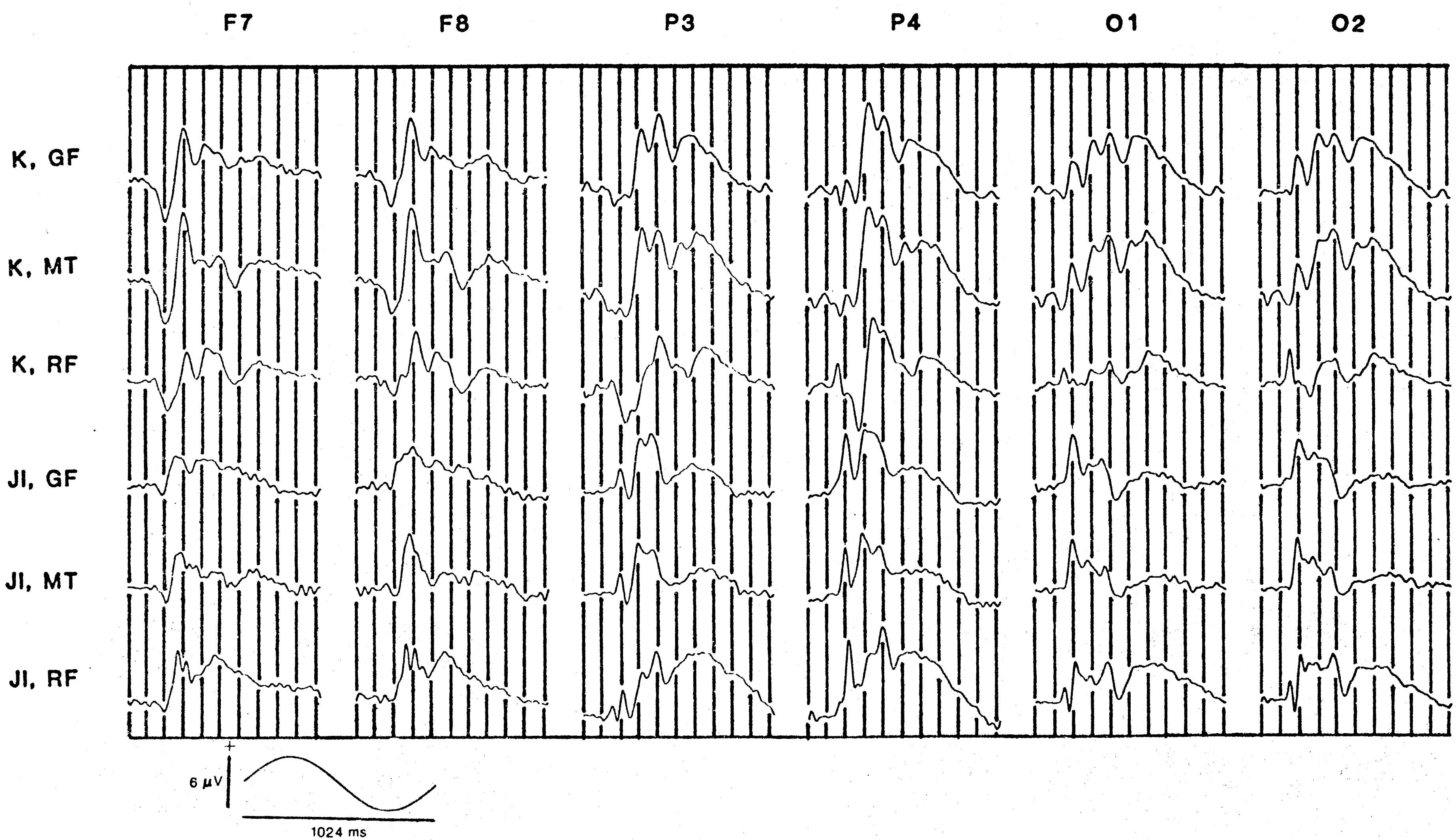

F7
F8
P3
P4
O1
O2
K, GF
K, MT
K, RF
JI, GF
JI, MT
JI, RF
+
6 µV
1024 ms

Figure 38. Meaningful and Nonsense Trigram Composite VERs from Subjects K and JI.

Subject K's meaningful trigram composite VERs (K, MT) are the sum and average of four meaningful trigram $\overline{\Sigma 64}$ VERs: from WAR, RAW, ART and RAT. Subject JI's meaningful trigram composite VERs (JI, MT) are also the sum and average of four meaningful trigram $\overline{\Sigma 64}$ VERs: from WAR, RAW, PIT and TIP. The nonsense trigram composite VERs from subjects K and JI (K, NT and JI, NT) are the sum and average of four nonsense trigram $\overline{\Sigma 64}$ VERs: from AWR, RWA, ATR, RTA and AWR, RWA, TPI, ITP respectively. The vertical lines are at 100 ms intervals beginning with each record's onset. Electrode positions label each column of composite VERs: from left to right F_7, F_8, P_3, P_4, O_1 and O_2.

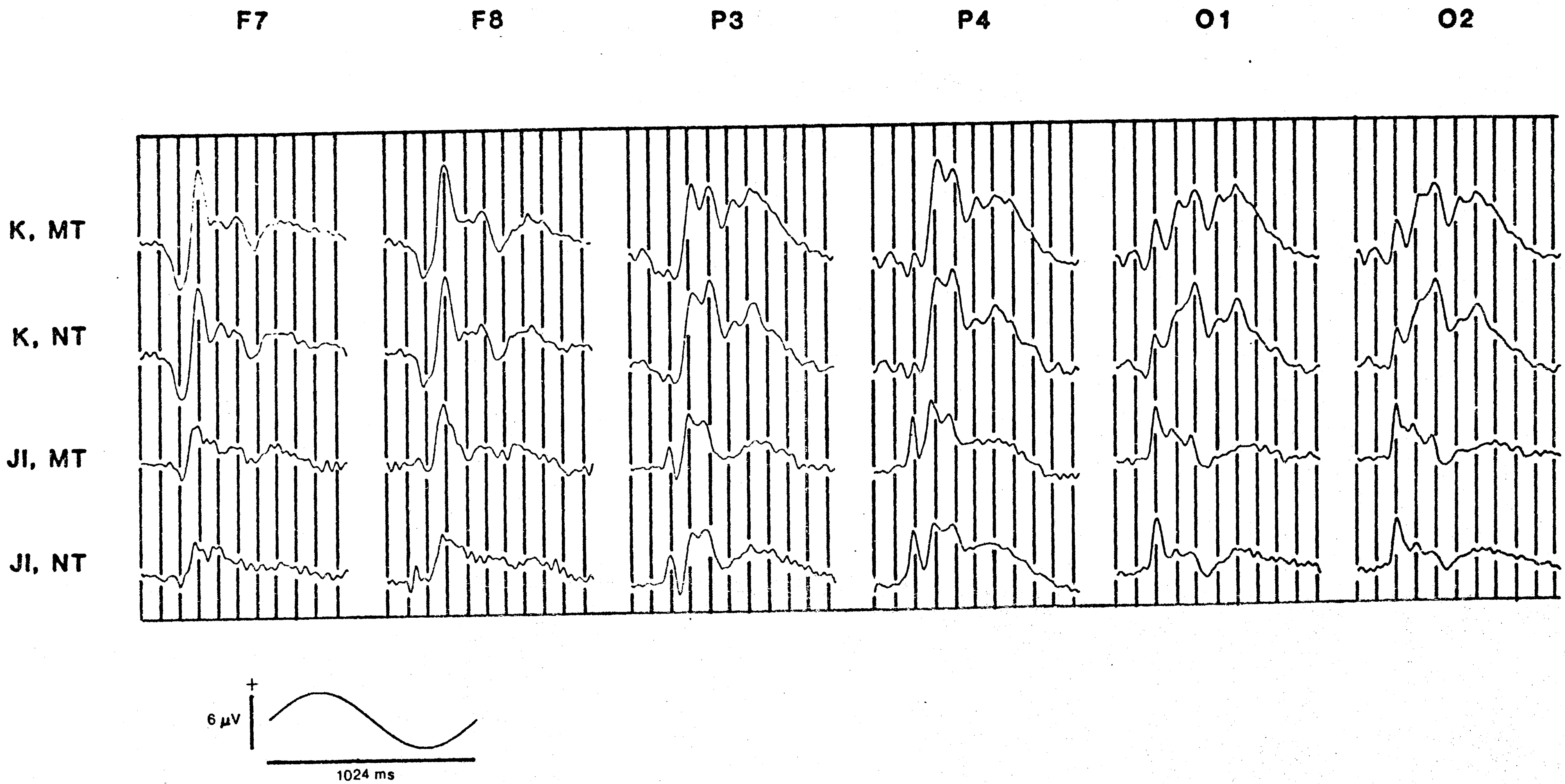
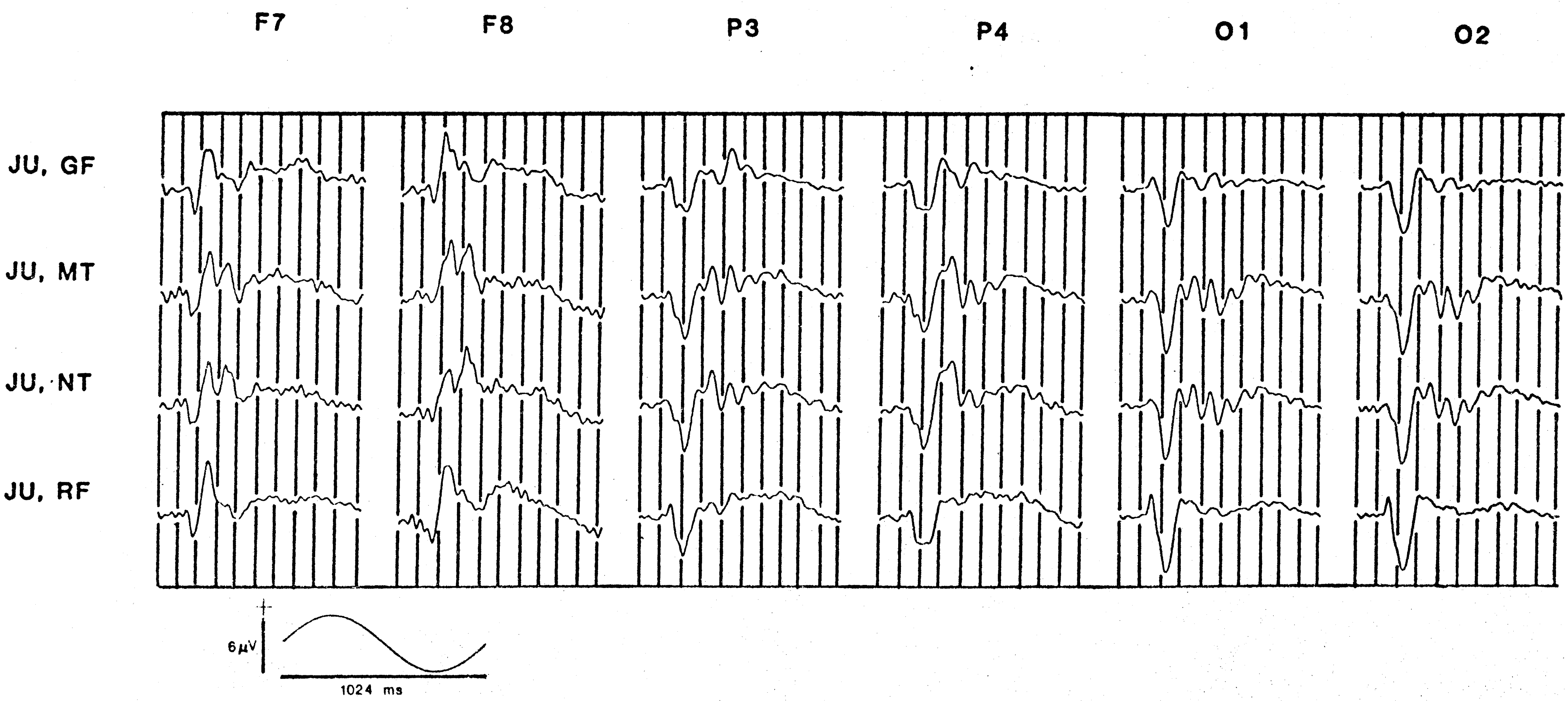

F7
F8
P3
P4
O1
O2
K, MT
K, NT
JI, MT
JI, NT
+
6 μV
1024 ms

Figure 39. Geometrical Figure, Meaningful Trigram, Nonsense Trigram and Reversible Figure Composite VERs from Subject JU.

Each of four rows of composite VERs is labeled by the subject's symbol, followed by the stimulus class producing each composite VER in the row (JU, GF; JU, MT; JU, NT; JU, RF). Each geometrical figure composite VER (GF) is the sum and average of six geometrical figure $\overline{\Sigma 64}$ VERs: from the small and large triangles, from the small and large squares; and fromthe small and large pentagons. The meaningful and nonsense trigram composite VERs (MT and NT) are the sum and average of four meaningful and nonsense trigram $\overline{\Sigma 64}$ VERs respectively (WAR, RAW, ART, RAT and AWR, RWA, ATR, RTA). Each reversible figure composite VER (RF) is the sum and average of four reversible figure interpretation and two solid figure $\overline{\Sigma 64}$ VERs: reversible wedge toward, reversible wedge away, stairs right side up, stairs upside down, solid wedge toward and solid wedge away. The vertical lines are at 100 ms intervals beginning with each record's onset. Electrode positions label each column of composite VERs: from left to right F_7, F_8, P_3, P_4, O_1 and O_2.


F7
F8
P3
P4
O1
O2
JU, GF
JU, MT
JU, NT
JU, RF
6µV
1024 ms

AWR, RWA, ATR and RTA, while for subject JI they resulted from AWR, RWA, TPI and ITP.

Components of the composite VERs will be defined as peaks and troughs. Each one considered will be designated by the letter P or T, followed by a number representing the number of millisecons from the onset of the record to the apex of the peak or trough. Three things need to be considered with this representation. First, these do not represent standard components as used in the VER literature. The stimulus presentation did not begin until 41.6 ms after recording onset. Secondly, the stimulus was not constant over time. There was a sinusoidal change in contrast over 101.6 ms. Thirdly, these time measurements of peaks and troughs should not be confused with latencies, even if a precise time during stimulus presentation is agreed on as representing comparable stimulus onset and time measurements correspondingly corrected for this. Peaks and troughs are likely the consequence of interacting multiple neural processes, the durations of which overlap in time. This obscures any true measurement of the onset of such processes in records such as these. To date, sources of the VER and its components are poorly understood.

E.1. Geometrical versus Reversible Figure Composite VERs.

There are clear and consistent differences between GF and RF composite VERs at electrode sites F_7 and F_8 for all subjects. Time from recording onset to a major trough (150 to 200 ms) and a major peak (200 to 320 ms) was greater for the RF than the GF components (Table 4A, in box). Peak-trough voltage differences for these same

Tables 4A - F. Geometrical Figure - Reversible Figure Composite VER Component Time and Voltage Difference Comparisons.

The times past record onset at which corresponding peaks or troughs occurred (P or T followed by time in milliseconds) in the geometrical figure (GF) and reversible figure (RF) composite VERs are shown in Tables 4A, 4C and 4E. Comparisons are shown for F_7 and F_8 electrode sites in Table 4A, for P_3 and P_4 electrode sites in Table 4C, and for O_1 and O_2 electrode sites in Table 4E. Comparisons from subjects K, JI and JU are given in each table. Where corresponding GF-RF differences show particular consistency in sign across subjects, the peak or trough times are enclosed in a box. In Table 4A, for example, F_7, RF times from record onset to a trough for subjects K, JI and JU (T212, T193 and T178 respectively) are consistently greater than F_7, GF times (T196, T192, T169) for all three subjects.

Tables 4B, 4D, and 4F are organized in the same way as Tables 4A, 4C, and 4E except that peak-trough voltage differences are to be compared instead of peak or trough times. For example, in Table 4B, subject K's F_7, GF value VP135-VT196=3.86 should be read: "The voltage difference between the peak at 135 ms and the trough at 196 ms is 3.86 μV." All voltage differences are given in microvolts. Where the sign of the difference between GF-RF voltage differences is particularly consistent across subjects, the values are enclosed in a box.

TABLE 4A

	F7 GF	F7 RF	F8 GF	F8 RF
K	P135	P141	P120	P142
	T196	T212	T185	T199
	P286	P315	P291	P315
	T339	T365	T366	T380
JI	P150	P136	P152	P151
	T192	T193	T180	T193
	P262	P265	P255	P265
	T340	T338	T384	T335
JU	P130	P144	P126	P142
	T169	T178	T154	T165
	P228	P248	P204	P239
	T279	T300	T278	T287
	T383	T405	T394	T420

TABLE 4B

	F7 GF	F7 RF	F8 GF	F8 RF
K	VP135-VT196=3.86	VP141-VT212=3.78	VP120-VT185=3.04	VP142-VT199=1.81
	VP286-VT196=10.73	VP315-VT212=6.68	VP291-VT185=10.06	VP315-VT199=7.34
	VP397-VT339=2.40	VP420-VT365=3.53	VP402-VT366=1.59	VP429-VT380=2.24
JI	VP150-VT192=1.30	VP136-VT193=1.24	VP152-VT180=0.82	VP151-VT193=0.65
	VP262-VT192=4.43	VP265-VT193=12.89	VP300-VT180=4.84	VP264-VT193=12.26
	VP262-VT340=1.99	VP265-VT338=3.77	VP300-VT384=2.39	VP265-VT381=3.83
JU	VP130-VT169=2.84	VP144-VT178=2.91	VP126-VT154=2.00	VP142-VT165=1.54
	VP228-VT169=6.86	VP248-VT178=8.22	VP204-VT154=7.66	VP239-VT165=8.42
	VP228-VT279=3.13	VP248-VT300=4.35	VP204-VT278=4.02	VP239-VT287=3.14

TABLE 4C

	P3 GF	P3 RF	P4 GF	P4 RF
K	P139	P150	P146	P158
	P232	P253	P200	P208
	T254	T271	T248	T270
	P324	P353	P318	P347
	T488	T473	T484	T471
JI	P141	P153	----	P166
	P196	P210	P199	P211
	T244	T247	T244	T244
	P300	P312	P300	P327
	T437	T437	T453	T450
JU	P138	P155	P126	P148
	P188	P192	----	----
	T226	T219	T224	T228
	P292	P302	P295	P308
	T387	T405	T393	T397

TABLE 4D

	P3 GF	P3 RF	P4 GF	P4 RF
K	----------------	VP150-VT119=1.05	VP146-VT119=0.98	VP158-VT118=2.73
	VP232-VT254=0.38	VP253-VT271=1.51	VP200-VT248=2.92	VP208-VT270=0.22
	VP324-VT254=4.82	VP353-VT271=6.64	VP318-VT248=11.50	VP347-VT270=12.92
JI	VP142-VT91=0.71	VP153-VT108=1.65	----------------	VP166-VT132=1.65
	VP196-VT244=3.37	VP210-VT247=3.19	VP199-VT244=5.15	VP211-VT275=5.39
	VP300-VT244=6.94	VP312-VT247=5.30	VP300-VT244=5.74	VP327-VT275=3.78
JU	VP138-VT115=0.99	VP155-VT132=1.34	VP126-VT102=0.57	VP148-VT129=0.71
	VP188-VT226=0.82	----------------	----------------	----------------
	VP292-VT226=4.45	VP302-VT219=5.30	VP295-VT224=5.56	VP308-VT228=4.71

TABLE 4E

	01 GF	01 RF	02 GF	02 RF
K	----	P153	P140	P155
	P203	P201	P198	P200
	T259	T267	T254	T264
	P316	P301	P313	P336
	P404	P401	P390	P394
	T476	T467	T470	T461
JI	P142	P152	P135	P153
	P199	P208	P194	P208
	T254	T268	T250	T271
	P285	P291	P287	P291
	P355	P385	P342	P382
	T430	T448	T427	T447
JU	P146	P159	P133	P154
	----	----	----	----
	T224	T235	T214	T230
	P289	P312	P290	P307
	P341	P356	P344	P346
	T392	T436	T389	T428

TABLE 4F

	01 GF	01 RF	02 GF	02 RF
K	----------------	VP152-VT124=1.86	VP140-VT117=0.35	VP155-VT100=4.11
	----------------	VP152-VT181=1.74	VP140-VT161=0.47	VP155-VT184=3.84
	VP203-VT154=4.24	VP201-VT181=0.53	VP198-VT161=4.53	VP199-VT184=0.35
	VP316-VT259=5.39	VP301-VT267=1.80	VP313-VT254=5.94	VP336-VT264=3.95
	VP404-VT358=2.51	VP401-VT346=1.41	VP390-VT354=1.44	VP394-VT376=0.41
JI	VP142-VT98=0.82	VP152-VT124=1.71	VP135-VT103=0.84	VP153-VT123=3.39
	----------------	VP152-VT176=2.64	VP135-VT149=0.24	VP153-VT179=2.89
	VP199-VT151=5.54	VP208-VT176=5.54	VP194-VT149=4.56	VP208-VT179=6.38
	VP285-VT254=1.25	VP291-VT268=0.59	VP287-VT250=0.82	VP291-VT271=0.31
	VP355-VT308=0.94	VP385-VT319=2.61	VP342-VT300=0.00	VP382-VT319=1.90
JU	VP146-VT109=1.17	VP159-VT130=2.29	VP133-VT87=0.71	VP154-VT97=1.93
	VP146-VT224=5.31	VP159-VT235=8.47	VP133-VT214=5.59	VP154-VT230=8.00
	----------------	----------------	----------------	----------------
	VP289-VT224=6.00	VP312-VT235=8.00	VP290-VT214=7.02	VP307-VT230=8.22
	VP341-VT324=0.24	VP356-VT334=0.37	VP344-VT333=0.12	VP346-VT327=0.18

components was greater in RF than GF composite VERs for subjects JU and JI. Equally large differences in the opposite direction were obtained for subject K (Table 4B). There were also other peak-trough differences differentiating GF from RF composite VERs for individual subjects that were not quite so general (Table 4B). A prominent double peak was apparent in subject JI's F_7 and F_8 RF composite VERs that was not evident in GF or MT and NT records (Figure 37; P265 and P311 for F_7, P265 and P312 for F_8). An early component was evident in subject K's RF composite VERs that was absent or much reduced in all his other composites (Figure 37; P141 for F_7, P142 for F_8).

Electrode sites P_3 and P_4 show a somewhat different picture when comparing GF and RF composite VERs. Time from record onset to a number of early peaks was greater in RF than in GF composite VERs for all subjects at both P_3 and P_4, conforming with results obtained from F_7 and F_8 (Table 4C, in box). However, results for troughs occurring during the first 500 ms of the records gave mixed results (Table 4C). With the exception of a very early peak occurring between 120 and 160 ms, no clear trend across subjects was evident when comparing peak-trough voltage differences between GF and RF composite VERs at electrode sites P_3 and P_4 (Table 4D).

At electrode sites O_1 and O_2, results from comparison of GF and RF are similar to those from F_7 and F_8. Early components of the RF composite VERs showed greater times from record onset to peak or trough than those of the GF composite VERs (Table 4E, in

box). Early peak-trough voltage differences were greater for RF than for GF composite VERs for all subjects (Table 4F, in box). Later peak-trough voltage differences were consistent across O_1 and O_2 in direction, for a given subject, but inconsistent across subjects (Table 4F). For every subject, a very early peak occurring between 150 and 160 ms was larger in the RF composite VERs than in the GF or MT and NT composite VERs. In some cases the peak was entirely absent (Figures 37, 38 and 39). Subject JI's RF composite O_1 and O_2 VERs showed decreased positive components at P291 (O_1 and O_2) relative to a second P385 and P382 component (O_1 and O_2 respectively). This was the case when compared with the same components in MT and NT as well as in GF composite VERs (Figures 37 and 38). Subject K showed much reduced P201, 301 and 401 amplitudes at O_1 and P199, 336, 394 amplitudes at O_2 in the RF composite VERs compared to GF, MT and NT composite VERs (Figure 37). Subject JI also showed an increased amplitude of a late, slow P700-750 component at both O_1 and O_2 in RF compared to GF, MT and NT composite VERs, while subject K showed a diminished P700-750 amplitude (Figure 37). Subject JU showed a diminished late slow P700-750 for both RF and GF composite VERs when compared with MT and NT (Figure 39).

E.2. Meaningful vs. Nonsense Trigram Composite VERs.

No consistent differences at electrode positions F_7 and F_8 were found across subjects regarding time from record onset to peaks or troughs when MT was compared with NT composite VERs. (Table 5A). However, major components were found that differentiated MT from NT

TABLES 5A-F. Meaningful Trigram - Nonsense Trigram Composite VER Component Time and Voltage Difference Comparisons.

The times past record onset at which corresponding peaks or troughs occurred (P or T followed by time in milliseconds) in the meaningful trigram (MT) and nonsense trigram (NT) composite VERs are shown in Tables 5A, 5C and 5E. Comparisons are shown for F_7 and F_8 electrode sites in Table 5A, for P_3 and P_4 electrode sites in Table 5C, and for O_1 and O_2 electrode sites in Table 5E. Comparisons from subjects K, JI and JU are given in each table. Where corresponding MT-NT differences show some consistency in sign across subjects, the peak or trough times are enclosed in a box. For example, in Table 5A, F_7 and F_8, NT times from record onset to a trough for subjects K, JI and JU (T204, T192 and T162 at F_7 respectively, and T186, T204 and T163 at F_8) are generally greater than corresponding F_7 and F_8, MT times (T197, T206, T157 at F_7 and T184, T203 and T152 at F_8).

Tables 5B, 5D, and 5F are organized in the same way as Tables 5A, 5C and 5E except that peak-trough voltage differences are to be compared instead of peak or trough times. For example, in Table 5B, subject K's F_7, MT value VP290-VT197=12.65 should be read: "The voltage difference between the peak at 290 ms and the trough at 197 ms is 12.65 μV." All voltage differences are given in microvolts. Where the sign of the difference between MT-NT voltage differences is particularly consistent across subjects, the values are enclosed in a box.

TABLE 5A

	F7 MT	F7 NT	F8 MT	F8 NT
K	P110	P110	P113	P116
K	T197	T204	T184	T186
K	P290	P288	P297	P294
K	T351	T343	T364	T362
JI	P143	P145	P159	P140
JI	T206	T192	T203	T204
JI	P264	P265	P284	P274
JI	----	----	----	----
JU	P97	P92	P81	P91
JU	P127	P130	P124	P140
JU	T157	T162	T152	T163
JU	P246	P248	P246	P247
JU	T286	T299	T282	T274
JU	P341	P332	P335	P324

TABLE 5B

	F7 MT	F7 NT	F8 MT	F8 NT
K	VP110-VT197=4.86	VP110-VT204=4.36	VP113-VT184=3.40	VP116-VT186=3.53
K	VP290-VT197=12.65	VP288-VT204=11.66	VP297-VT184=12.11	VP294-VT186=11.57
JI	VP143-VT206=2.00	VP159-VT192=1.30	VP159-VT203=1.35	VP140-VT204=1.65
JI	VP264-VT206=5.57	VP265-VT192=4.98	VP297-VT203=7.07	VP274-VT204=6.30
JU	VP127-VT157=2.61	VP130-VT162=2.59	VP124-VT152=0.98	VP140-VT163=1.34
JU	VP246-VT157=6.90	VP248-VT162=6.63	VP246-VT152=6.67	VP247-VT163=5.61
JU	VP341-VT286=2.41	VP332-VT299=3.29	VP335-VT282=3.30	VP324-VT274=4.94

TABLE 5C

	P3 MT	P3 NT	P4 MT	P4 NT
K	P146	----	P137	P136
	P190	P189	P205	P205
	T224	T221	T241	T234
	P311	P306	P315	P314
	T463	T468	T462	T463
	P522	P517	P517	P512
JI	----	----	----	----
	P190	P195	P190	P194
	T226	T242	T223	T246
	P287	P303	P285	P297
	T462	T450	T443	T451
	----	----	----	----
JU	P134	P127	P136	P133
	P179	P184	P178	P178
	T220	T223	T213	T215
	P289	P292	P303	P309
	T401	T408	T408	T403
	P443	P450	P447	P445

TABLE 5D

	P3 MT	P3 NT	P4 MT	P4 NT
K	VP190-VT171=0.82	VP189-VT164=0.82	VP205-VT171=2.47	VP205-VT172=1.65
	VP311-VT224=10.17	VP306-VT221=9.60	VP315-VT241=11.40	VP314-VT234=10.07
JI	VP190-VT153=2.33	VP195-VT152=2.94	VP190-VT142=5.40	VP194-VT122=5.84
	VP287-VT226=6.96	VP303-VT242=6.67	VP285-VT222=6.16	VP297-VT246=5.05
JU	VP134-VT112=0.71	VP127-VT93=0.47	VP136-VT115=0.95	VP133-VT113=0.29
	VP179-VT220=2.33	VP184-VT223=3.35	VP178-VT213=1.87	VP178-VT215=2.71
	VP289-VT220=5.89	VP292-VT223=6.68	VP303-VT213=6.58	VP309-VT215=8.52
	VP443-VT401=4.12	VP450-VT408=2.95	VP447-VT408=3.04	VP445-VT403=1.78

TABLE 5E

	01 MT	01 NT	02 MT	02 NT
K	P194	P191	P198	P199
	T250	T235	T247	T237
	P312	P305	P313	P314
	P392	P391	P380	P386
	----	----	----	----
	T459	T463	T456	T462
JI	P194	P203	P192	P191
	T248	T261	T250	T261
	P277	P294	P275	P290
	P369	P367	P370	P367
	----	----	----	----
	T463	T452	T458	T462
JU	P145	P150	P129	P132
	T226	T225	T219	T217
	P294	P293	P291	P294
	P360	P366	P356	P356
	P447	P450	P439	P443
	T495	T492	T490	T485

TABLE 5F

	01 MT	01 NT	02 MT	02 NT
K	VP194-VT145=5.28	VP191-VT146=4.63	VP198-VT150=4.66	VP199-VT155=4.35
	VP312-VT250=5.22	VP305-VT235=3.89	VP313-VT247=5.69	VP314-VT237=4.59
JI	VP194-VT147=5.59	VP203-VT149=5.49	VP192-VT147=5.92	VP191-VT147=5.68
	VP277-VT248=0.85	VP294-VT261=0.85	VP275-VT250=0.82	VP290-VT261=0.82
JU	VP145-VT112=1.32	VP150-VT95=0.94	VP129-VT100=0.88	VP132-VT92=0.94
	VP294-VT226=7.41	VP293-VT225=7.66	VP291-VT219=7.36	VP294-VT217=8.30
	VP447-VT495=3.86	VP450-VT492=3.53	VP439-VT490=3.42	VP443-VT485=2.94

composite VERs for individual subjects (Table 5A, in box). The most consistent differences between the MT and NT composite VERs at F_7 and F_8 for all subjects were with regard to peak-trough voltage differences. These voltage differences favored MT over NT (Table 5B, in box).

No consistent differences in time to peaks or troughs were found at P_3 or P_4 electrode sites across subjects that differentiated MT from NT composite VERs. However, individual differences were found that differentiated the two, particularly for subjects JU and JI. In general, greater times for MT components were found for these subjects (Table 5C). An inconsistent pattern across subjects was also found with respect to direction of peak-trough voltage differences, although consistent direction of voltage differences across electrode sites for particular components was evident within subjects (Table 5D). By observation, subject JU's MT and NT composite VERs at P_3 and P_4 were more similar in appearance (pattern of components) to each other than either was to GF or RF composite VERs (Figure 39). This is even more obvious at electrode positions O_1 and O_2. It is important to note that this similarity between composite VERs exists even though the constituent VERs of each were obtained during completely different sessions, in completely different stimulus matrices, and from stimuli whose elements were in different order. There is a positive component in subject K's MT and NT composite VERs (P521, 518 in P_3, and P517, 512 in P_4 respectively) that is absent in GF P_3 and P_4. This component may show

in RF P_3 and P_4, shifted somewhat toward the left (P493, 491 respectively) and overlapping with P403 at P_3 and P405 at P_4 (Figure 37).

Differences in time to peaks or troughs between MT and NT composite VERs at electrode sites O_1 and O_2 showed mixed results across subjects, and to a lesser extent across electrode positions (Table 5E). An early positive component, P140 to P210 at O_1 and P120 to P200 at O_2, gave greater peak-trough voltage differences for MT than NT composite VERs for all subjects at both electrode sites except for subject JU at O_2 (Table 5E, in box). Other components showed mixed results in direction of peak-trough voltage differences across subjects, but consistent differences in direction across electrode sites for a given subject and a given component (Table 5E). None of the subjects showed different components in MT versus NT composite VERs. However, as mentioned above, there is a striking similarity in appearance of subject JU's MT and NT composite VERs between 300 and 700 ms that is different from the GF and RF composite VERs (Figure 39). A long, slow P700-750 component was of greater amplitude in MT and NT than RF and GF composite VERs for subject JU (Figure 39). Subject K had a double peak in MT and NT composite VERs at approximately P520 and P600 at O_1 and O_2 that was absent in GF and RF composite VERs.

E.3. Hemispheric Comparison of Composite VERs.

Time to an F_7 composite VER negative component occurring between 150 and 210 ms was greater than or equal to the time to the corres-

ponding F_8 component for all subjects and all stimulus classes (Table 6A, in box). A major positive component of the composite VERs occurring between 220 and 320 ms did not show such consistent results. Direction of difference between F_7 and F_8 times to this component was fairly consistent across stimulus classes for any particular subject, but was not consistent across subjects (Table 6A). F_7 peak-trough voltage differences between two very early components (P110-160, T150-210) were greater than their F_8 counterparts for every stimulus class and every subject except one, stimulus class NT, subject JI (Table 6B, in box). This was not the case for other peak-trough voltage differences, which gave mixed results (Table 6B).

Somewhat different results were found for P_3 and P_4 composite VER comparisons. No consistent direction of peak or trough time differences was found across subjects or stimulus classes (Table 6C). The direction of differences between P_3 and P_4 peak-trough voltage differences for a particular component tended to be consistent across stimulus classes for any given subject, but they were not consistent across subjects (Table 6D, in box). This was most dramatically shown in one of subject JI's early components peaking between 190 and 210 ms. The P_4 composite VER peak-trough voltage differences were much greater than P_3 across all stimulus classes (Table 6D, in box; Figure 37). A small positive component occurring at 260 ms in subject JI's P_4 RF composite VER was not evident in his P_3 RF composite VER (Figure 37). This component was also evident in subject JI's P_4, but not P_3, $\overline{\Sigma 64}$ constituent reversible figure VERs (Figure 34). It did not, however, show in either of the P_3 $\overline{\Sigma 64}$ solid wedge toward or solid wedge away constituent VERs. Subject K's P_4 RF composite

Tables 6A-F. Hemispheric Comparisons of Composite VERs.

The times past record onset at which corresponding peaks, troughs, or sharp breaks in slope occurred (P, T, or B followed by time in milliseconds) in the hemispheric comparisons of composite VERs are shown in Tables 6A, 6C and 6E. Comparisons between F_7 and F_8 electrode sites are shown in Table 6A, between P_3 and P_4 electrode sites in Table 6C, and between O_1 and O_2 electrode sites in Table 6E. Comparisons from each of the stimulus classes (geometrical figure, GF; meaningful trigram, MT; nonsense trigram, NT; and reversible figure, RF) and from each of the subjects (K, JI and JU) are given in each table. Where corresponding left-right differences (F_7-F_8, P_3-P_4, or O_1-O_2) show particular consistency in sign across subjects, the peak or trough times are enclosed in a box. In Table 6A, for example, F_7, GF times from record onset to a trough for subjects K, JI and JU (T196, T192 and T169 respectively) are consistently greater than corresponding F_8, GF times for all subjects.

Tables 6B, 6D and 6F are organized in the same way as Tables 6A, 6C and 6E except that peak-trough voltage differences are to be compared instead of peak or trough times. For example, in Table 6B, subject K's F_7, GF value VP135-VT196=3.86 should be read: "The voltage difference between the peak at 135 ms and the trough at 196 ms is 3.86 μV." All voltage differences are given in microvolts. Where the sign of the difference between hemispheric (F_7-F_8, P_3-P_4, or O_1-O_2) voltage differences is particularly consistent across subjects, the values are enclosed in a box.

TABLE 6A

		F7	F8	F7	F8	F7	F8
GF	K	P135	P120	T196	T185	P286	P291
	JI	P150	P152	T192	T180	P262	P300
	JU	P130	P126	T169	T154	P228	P204
MT	K	P110	P113	T212	T199	P290	P297
	JI	P143	P159	T193	T193	P264	P284
	JU	P127	P124	T178	T165	P246	P246
NT	K	P110	P116	T197	T184	P288	P294
	JI	P159	P140	T206	T203	P265	P274
	JU	P130	P140	T157	T152	P248	P247
RF	K	P141	P142	T204	T186	P315	P315
	JI	P136	P151	T192	T204	P265	P265
	JU	P144	P142	T162	T163	P248	P239

TABLE 6B

		F7	F8	F7	F8
GF	K	VP135-VT196=3.86	VP120-VT185=3.04	VP286-VT196=10.73	VP291-VT185=10.06
	JI	VP150-VT192=1.30	VP152-VT180=0.82	VP262-VT192=4.43	VP300-VT180=4.84
	JU	VP130-VT169=2.84	VP126-VT154=2.00	VP228-VT169=6.86	VP204-VT154=7.66
MT	K	VP110-VT197=4.86	VP113-VT184=3.40	VP290-VT197=12.65	VP297-VT184=12.11
	JI	VP143-VT206=2.00	VP159-VT203=1.35	VP264-VT206=5.57	VP297-VT203=7.07
	JU	VP127-VT157=2.61	VP124-VT152=0.98	VP246-VT157=6.90	VP246-VT152=6.67
NT	K	VP110-VT204=4.36	VP116-VT186=3.53	VP288-VT204=11.66	VP294-VT186=11.57
	JI	VP159-VT192=1.30	VP140-VT204=1.65	VP265-VT192=4.98	VP274-VT204=6.30
	JU	VP130-VT162=2.59	VP140-VT163=1.34	VP248-VT162=6.63	VT247-VT163=5.61
RF	K	VP141-VT212=3.78	VP142-VT199=1.81	VP315-VT212=6.68	VP315-VT199=7.34
	JI	VP136-VT193=1.24	VP151-VT193=0.65	VP265-VT193=12.89	VP264-VT193=12.26
	JU	VP144-VT178=2.91	VP142-VT165=1.54	VP248-VT178=8.22	VP239-VT165=8.42

TABLE 6C

		P3	P4	P3	P4	P3	P4
GF	K	P232	P200	T254	T248	P324	P318
	JI	P196	P199	T244	T244	P300	P300
	JU	P138 B188	P126 ----	T226	T224	P292	P295
MT	K	P190	P205	T224	T241	P311	P315
	JI	P190	P190	T226	T223	P287	P285
	JU	P134 B179	P136 B178	T220	T213	P289	P303
NT	K	P189	P205	T221	T234	P306	P314
	JI	P195	P194	T242	T246	P303	P297
	JU	P127 B184	P133 B178	T223	T215	P292	P309
RF	K	P253	P208	T271	T270	P353	P347
	JI	P210	P211	T247	T244	P312	P327
	JU	P155 B192	P148 ----	T219	T228	P302	P308

TABLE 6D

		P3	P4	P3	P4
GF	K	VP232-VT254=0.38	VP200-VT248=2.92	VP324-VT254=4.82	VP318-VT248=11.50
	JI	VP196-VT244=3.37	VP199-VT244=5.15	VP300-VT244=6.94	VP300-VT244=5.74
	JU	VP188-VT226=0.82	----------------	VP292-VT226=4.45 VP449-VT387=3.88	VP295-VT224=5.56 VP460-VT393=2.77
MT	K	VP190-VT171=0.82	VP205-VT171=2.47	VP311-VT224=10.17	VP315-VT241=11.40
	JI	VP190-VT153=2.33	VP190-VT142=5.40	VP287-VT226=6.96	VP285-VT222=6.16
	JU	VP179-VT220=2.33	VP178-VT213=1.87	VP289-VT220=5.89 VP443-VT401=4.12	VP303-VT213=6.58 VP447-VT408=3.04
NT	K	VP189-VT164=0.82	VP205-VT172=1.65	VP306-VT221=9.60	VP314-VT234=10.07
	JI	VP195-VT152=2.94	VP194-VT122=5.84	VP303-VT242=6.67	VP297-VT246=5.05
	JU	VP184-VT223=3.35	VP178-VT215=2.71	VP292-VT223=6.68 VP450-VT408=2.95	VP309-VT215=8.52 VP445-VT403=1.78
RF	K	VP253-VT271=1.51	VP208-VT270=0.22	VP353-VT271=6.64	VP347-VT270=12.92
	JI	VP210-VT247=3.19	VP211-VT244=5.39	VP312-VT247=5.30	VP327-VT275=3.78
	JU	----------------	----------------	VP302-VT219=5.30 VP468-VT405=2.40	VP308-VT228=4.71 VP458-VT397=1.24

TABLE 6E

		01	02	01	02	01	02	01	02
GF	K	----	P140	P203	P198	T259	T254	P316	P313
	JI	P142	P135	P199	P194	T254	T250	P285	P287
	JU	P146	P133	----	----	T224	T214	P289	P290
MT	K	----	----	P194	P198	T250	T247	P312	P313
	JI	----	----	P194	P192	T248	T250	P277	P275
	JU	P145	P129	P145	P129	T226	T219	P294	P291
NT	K	----	----	P191	P199	T235	T237	P305	P314
	JI	P135	P135	P203	P191	T261	T261	P294	P290
	JU	P150	P132	P150	P132	T225	T217	P293	P294
RF	K	P153	P155	P201	P200	T267	T264	P301	P336
	JI	P152	P153	P208	P208	T268	T232	P291	P291
	JU	P159	P154	----	----	T235	T230	P312	P307

TABLE 6F

		01	02	01	02
GF	K	VP203-VT154=4.24	VP198-VT161=4.53	VP316-VT259=5.39	VP313-VT254=5.94
	JI	VP142-VT98=0.82	VP135-VT103=0.84	VP199-VT151=5.54 VP285-VT254=1.25	VP194-VT149=4.56 VP287-VT250=0.82
	JU	VP146-VT109=1.17	VP133-VT87=0.71	VP289-VT224=6.00	VP290-VT214=7.02
MT	K	VP194-VT145=5.28	VP198-VT150=4.66	VP312-VT250=5.22	VP313-VT247=5.69
	JI	VP194-VT147=5.59	VP192-VT147=5.92	VP194-VT147=5.59 VP277-VT248=0.85	VP192-VT147=5.92 VP275-VT250=0.82
	JU	VP145-VT112=1.32	VP129-VT100=0.88	VP294-VT226=7.41	VP291-VT219=7.36
NT	K	VP191-VT146=4.63	VP199-VT155=4.35	VP305-VT235=3.89	VP314-VT237=4.59
	JI	VP203-VT149=5.49	VP191-VT147=5.68	VP203-VT149=5.49 VP294-VT261=0.85	VP191-VT147=5.68 VP290-VT261=0.82
	JU	VP150-VT95=0.94	VP132-VT92=0.94	VP293-VT225=7.66	VP294-VT217=8.30
RF	K	VP153-VT124=1.86	VP155-VT100=4.11	VP301-VT267=1.80	VP336-VT264=3.95
	JI	VP152-VT124=1.71	VP153-VT123=3.39	VP208-VT176=5.54 VP291-VT268=0.59	VP208-VT179=6.38 VP291-VT271=0.31
	JU	VP159-VT130=2.29	VP154-VT97=1.93	VP312-VT235=8.00	VP307-VT230=8.22

VER was quite different from his P_3 RF composite VER. A P_4 peak occurring at 347 ms was sharply reduced in amplitude in P_3, 353 ms (Figure 37). A peak occurring at 208 ms in subject K's RF P_4 composite VER was shifted to 253 ms in the corresponding P_3 composite VER (Figure 37). These differences were also characteristic of his Σ64 constituent reversible figure VERs, including the solid wedges toward and away (Figure 33). Subject JU showed a flattening of her RF P_4 composite VER N213 component that was not seen in the corresponding RF P_3 composite VER (Figure 39). That this may be the result of an interacting, small amplitude component is evident in the constituent Σ64 reversible figure VERs (Figure 35).

Only one O_1 and O_2 composite VER component had moderately consistent directions of difference in time to a peak or trough across both subjects and stimulus classes. This was a negative component occurring between 210 and 270 ms (Table 6E, in box). A comparison of O_1 and O_2 composite VER peak-trough voltage differences was characterized by inconsistency across subjects. However, an early peak occurring between 140 and 210 ms did show some within subject consistency across stimulus classes; O_1 showing the greater peak-trough voltage differences for subject JU and O_2 showing the greater peak-trough voltage differences for subject JI (Table 6F). With the exception of subject K, no major differences in appearance of O_1 and O_2 was evident. Subject K had a prominant O_2 RF N264 component that was much reduced in the O_1 RF composite VER (Figure 37). This difference also characterized O_1 and O_2 differences in this subject's

$\overline{\Sigma 64}$ reversible figure constituent VERs (Figure 33).

E.4. Relation of Two Early Components in O_1 and O_2 Composite VERs.

Two early components in the O_1 and O_2 composite VERs, the first appearing between 120 and 160 ms and the second between 140 and 210 ms, had an interesting relationship to one another when the signed difference between their voltages was compared with stimulus class (Table 7; Figures 37, 38 and 39). The first component was defined as a peak. The second component was also defined as a peak for subjects JI and K, but as a sharp change in slope (break) for subject JU (Figures 37, 38, and 39). Voltage differences were defined as the voltage of the first component minus the second. An "a" in Table 7 indicates that the component in question could not be isolated in the record.

In every case where the first component could be isolated, the voltage difference was greater in the RF than GF composite VERs; that is, for every subject at both electrode sites. Subject JU's voltage differences were less for MT and NT composite VERs than they were for either the GF or RF composite VERs. The first component could not be isolated in either the MT or NT O_1 and O_2 composite VERs of subjects JI and K (Table 7; Figures 37, 38 and 39). The possible implications of this will be discussed in the discussion section.

Table 7. Voltage Difference Relation of Two Early, Positive Components in O_1 and O_2 Composite VERs.

The difference in voltage (in microvolts) between two early, positive components of the geometrical figure (GF), meaningful trigram (MT), nonsense trigram (NT), and reversible figure (RF) composite VERs is shown for each subject (K, JI and JU). P, followed by a time (in milliseconds) from record onset to a composite VER component refers to a peak, while B refers to a sharp change in slope. For example, JU's O_1, GF value VP146-VB170=+1.43 should be read: "The voltage difference between the peak occurring at 146 ms and the sharp change in slope occuring at 170 ms is plus 1.43 µV." An "a" in the table means that one or both of the components in question could not be isolated in the composite VER record. Note that the voltage difference value at RF was greater than the voltage difference value at GF for every subject at both the O_1 and O_2 electrode sites except for subject K's O_1, GF value, where the component could not be isolated.

TABLE 7

		01	02
K	GF	a	VP140-VP198=-4.06
	MF	a	a
	NT	a	a
	RF	VP152-VP201=+1.21	VP155-VP199=+3.49
JI	GF	VP142-VP199=-5.54	VP135-VP194=-4.32
	MT	a	a
	NT	a	a
	RF	VP152-VP208=-2.90	VP153-VP208=-3.49
JU	GF	VP146-VB170=+1.43	VP133-VB168=+2.70
	MT	VP145-VB149=+0.06	VP129-VB153=+1.20
	NT	VP150-VB167=+0.37	VP122-VB168=+1.60
	RF	VP159-VB194=+4.74	VP154-VB186=+4.53

DISCUSSION

A. Review

Several strategies were employed in this study to determine whether or not form perception and meaning of visual stimuli have a discernable systematic effect on the VER. A secondary purpose was to lay a basis for future, narrower studies designed to confirm or deny the conclusions drawn here and isolate variables affecting this study's outcome. Four basic stimulus classes were used in this investigation, each designed to answer some particular set of questions: control stimuli, geometrical figures, trigrams, and reversible figures. Three highly trained and motivated adult subjects were intensly studied over a 1 - 1½ year period.

Results from section A, Control Data, provided information about extraneous factors that might have influenced the experimental results. Blank stimulus VERs from subjects JU and JI were clearly "flat," showing only random activity (Figures 13 and 14). Subject K's blank VERs, however, show a small response (Figure 12). Every effort was made to isolate its cause (vocalization, subvocalization, muscle artifact, blinking, eye movement artifact, stray light, electrical artifact, extraneous noise, etc.) and none could be found. In as much as the response was small and replicable and VER analysis would be based on VER differences, it was concluded that it would have no systematic effect on this study's results. The background only VERs, resulting from a sinusoidal change in luminance of approximately 2 cd/m^2, produced a repeatable, small amplitude VER (Figures 12, 13, and 14). These VERs, when compared with those resulting from a figure, flash +, or flash -, clearly show

that the background only VER was not saturated, eliminating any plateau effects. Background only VERs were taken to be constant and therefore, to have no systematic effects on the results of this study. Observation of control figure VERs show that control sessions produced VERs similar in all respects to those obtained during experimental sessions (Figures 12, 13, 14, 15 and 16). It may be concluded that the control stimulus matrix did not bias control results. Control figure VERs were found to be significantly different from blank and background only VERs for all subjects at all electrode sites (Figure 17). The flash + and flash - VERs obtained in this laboratory were similar to those obtained from other laboratories using similar recording techniques (Wicke, Donchin and Lindsley, 1964; Vaughan and Hull, 1965; DeVoe, Ripps and Vaughan, 1968; Kitajima, Morotomi and Kanoh, 1975; Morotomi and Kitajima, 1975).

The data analysis used in this study has not been used in other laboratories. As the conclusions drawn here depend on the validity and adequacy of the analysis, it will be reviewed. The analysis was developed for a variety of reasons. I wished to investigate intensively a very small number of subjects using each one as his own control in an N = 1 systematic replications design (Sidman, 1960). Two subjects were independently presented the same set of stimuli while a third was presented a mix of the same and similar, but different stimuli. VERs taken from the same subject are highly correlated. They are not independent. Due to this and

a small N the more familiar parametric designs could not be used. As I wished to use an analysis that would detect differences in wave form, the problem of definition became a serious one. After careful consideration of what must be meant by such an analysis, I decided to base the statistical design on an analysis of Fourier components (Appendix A). Initially both frequency amplitude and phase were to be considered. However, phase proved to be too variable due to the nature of the arctangent function, small differences in the VERs producing too large a difference in phase, considering the range of possible differences allowed.* This was not the case for frequency amplitudes, so the analysis was restricted to these. A last consideration was based on the possiblity that specific frequency components might vary systematically with stimulus variables. For this reason the analysis procedure used was favored over cross correlation.

The logic of the waveform analysis was simple. Each $\overline{\Sigma 32}$ VER form was defined by a sequence of 29 frequency component amplitudes, determined by Fourier Analysis. Each $\Sigma 32$ VER produced by a particular stimulus and subject was replicated during a different session within the context of a different stimulus matrix. This provided two frequency amplitude sequences associated with each stimulus and

*The variance of phase differences decreased as the number of EEG records contributing to the VER increased. Although the number of records required precluded the use of phase in this study, a study allowing a large sample, and one not plagued with problems such as habituation, adaptation, loss of attention, etc. resulting from stimulus repetition might well use such a sensitive measure.

subject. The difference between and the mean of each of the corresponding frequency amplitudes in the two sequences was then calculated. This produced a mean frequency amplitude sequence and a difference between frequency amplitudes sequence associated with each stimulus presented to a subject. The difference between frequency amplitudes sequence (D sequence) was an estimate of error. These last two sequences formed the basis of the statistical analysis. VERs resulting from two different stimuli were considered distinct if and only if the absolute value of one or more of the differences between their corresponding mean frequency amplitudes exceeded the absolute values of both their corresponding differences between frequency amplitudes (in the D sequences associated with each stimulus).

Based on this analysis procedure a number of conclusions were drawn:

1. Dark line geometrical figures of the same perimeter, restricted to the macula, but having different shape, produce distinctly different VERs.
    a. This was true for all subjects.
    b. This was true at all electrode sites.
    c. This was true for the majority of subjects at each electrode site.
    d. This was true for both the "large" and "small" geometrical figure sets.
2. Dark line geometrical figures of the same shape,

restricted to the macula, but having different angular subtense (one set of figures having twice the perimeter of the other) produce distinctly different VERs.

a. This was true for all subjects.

b. This was true at all electrode sites.

c. This was true for the majority of subjects at each electrode site.

3. There was no evidence to support the contention that there is a greater degree of difference (in terms of number of subjects, number of frequency components, or size of frequency component differences showing difference) between dark line geometrical figures, restricted to the macula, of different shape, but the same angular subtense, than between dark line geometrical figures, restricted to the macula, of the same shape, but different angular subtense.

   a. This was true for all subjects.

   b. This was true at all electrode sites.

   c. This was true for the majority of subjects at each electrode site.

4. No pattern of frequency components associated with the differences in geometrical figure features such as number of edges, number of corners, number of oblique lines, number of horizontal and vertical lines, or presence of curved lines was evident.

5. Different orders of three dark line trigram letters, restricted to the macula, produce distinctly different VERs.

   a. This was true for all subjects.

   b. This was true at all electrode sites.

   c. This was true for the majority of subjects at each electrode site.

6. There was no evidence to support the contention that there is a greater degree of difference between meaningful (word) trigrams and nonsense (nonword) trigrams than there is between the meaningful or between the nonsense trigrams.

   a. This was true for all subjects.

   b. This was true at all electrode sites.

   c. This was true for the majority of subjects at each electrode site.

7. There was no evidence to support the contention that there was a greater or lesser degree of difference between the meaningful trigrams than between the nonsense trigrams.

   a. This was true for all subjects.

   b. This was true at all electrode sites.

   c. This was true for the majority of subjects at each electrode site.

8. No pattern of frequency components associated with

the differences in the letter order was evident.

9. The solid wedge away produced a distinctly different VER from the solid wedge toward.
    a. This was true for all subjects.
    b. This was true at all electrode sites.
    c. This was true for the majority of subjects at each electrode site.
10. The solid wedges produced distinctly different VERs from those produced by the corresponding reversible wedge interpretation.
    a. This was true for all subjects.
    b. This was true at all electrode sites.
    c. This was true for the majority of subjects at each electrode site.
11. VERs produced by the different orientations of the reversible figures are distinctly different.
    a. This was true for all subjects.
    b. This was true at all electrode sites.
    c. This was true for the majority of subjects at each electrode site except F_7, where three out of a possible 6 differences were shown.
12. A number of individual differences in the patterns of electrode sites at which VER differences were demonstrated is apparent. This was true for comparisons made in all stimulus classes.

Following the waveform analysis $\overline{\Sigma 64}$ VERs within a stimulus class were summed and averaged, forming composite VERs. The composite VER peak-trough voltage differences and times from record onset to peaks or troughs were compared. The following tentative conclusions based on these comparisons were reached:

1. The composite geometrical figure and reversible figure VERs at corresponding electrode sites are different from one another. This was true for every subject at every electrode site.
2. The composite meaningful and nonsense trigram VERs at corresponding electrode sites are different from one another. This was true for every subject at every electrode site. However, these differences were not as great in number or as consistent as for the geometrical figure - reversible figure comparisons.
3. Meaningful trigram and nonsense trigram composite VERs are different from geometrical figure and reversible figure composite VERs. For all subjects this was most evident at electrode sites P_3, P_4, O_1 and O_2.
4. Hemispheric differences in the composite VERs are evident at all electrode sites for all subjects. However, there were a considerable number of individual differences regarding the components involved and the nature and direction of difference in this sample.

In addition to the above conclusions, two general observations

that were made during the course of this study are important. The first is that VERs obtained from any one electrode site, but from different subjects appeared very dissimilar in form; whereas VERs obtained from the same electrode site and the same subject appeared very similar, even when VERs from different stimuli were compared (see Figures 32, 33, 34 and 35). Further, the nature of differences between VERs obtained from different stimuli were not the same for all subjects. Differences appeared in the pattern and magnitude of frequency amplitude differences for the different subjects (Appendixes C through F). Differences were also apparent in comparisons of the composite VERs: in direction of the differences in peak-trough voltage differences; in the direction of differences in the times from VER onset to peaks or troughs; and to some extent, differences in the components themselves (Tables 4, 5, and 6; Figures 37, 38 and 39). The second observation is that VERs obtained from the same subject, the same stimulus, and the same electrode site, but during different sessions (some separated in time by many months) were very much alike in appearance (Figures 12, 13, 15, 16, 30 and 31). No difference was found in degree of difference between replicated VERs related to time between sessions (based on comparisons of error distributions of VERs replicated during sessions separated by days, weeks and months).

The first observation confirms the use of the waveform analysis on several grounds. Designs based on a comparison of group

means* and/or requiring independence of samples and isolation of a particular dependent variable cannot be used without great risk. The problem in isolation of a particular independent variable combined with the error distributions shown in Appendixes also suggests heterogeneity of variance. These problems preclude use of many of the more familiar parametric designs. This observation also restricts the kinds of experimental questions that might be asked. In this study, across subjects comparisons took the form of: "How many subjects showed a difference between....., regardless of the kind of difference." This approach recognizes the possibility that VERs may not reflect simple, stereotyped physiological responses of subjects. The second observation, that replicated VERs obtained some weeks or months apart appear very similar in form, is important because it was enduring differences in VER form associated with visual form perception and meaning that were sought. Assuming adequate control for the effects of a stimulus repetition, there is a philosophical as well as scientific issue here. Subjectively the visual form perception and meaning of stimuli used in this study seem to persist over considerable periods of time with little change. It seems questionable to me that an individual's neural processes related to perception and meaning of these visual forms would be tenuous and fleeting. If these processes are reflected

*It was evident that the direction of differences between composite VERs was often inconsistent across subjects, even when consistent across electrode sites or stimulus comparisons for a given subject. Group means might well mask such differences.

in the VER I see little reason to believe that time between sessions would be a factor prohibiting their detection.

B. Interpretation

As this was an exploratory study, several strategies were employed in an effort to isolate possible VER correlates of visual form perception and meaning. The first strategy was based on the one employed by John, Herrington and Sutton (1967). They found that VERs obtained from the same geometrical figure shape, but different angular subtense, were more alike than VERs obtained from different geometrical figure shapes equated for total area. They concluded from these findings that their VER differences "seem to constitute a physiological correlate of perceptual rather than sensory processes." The geometrical figure data from this study does not confirm their findings nor support their conclusions. Geometrical figure data from this study would support the conclusion that differences in stimulus parameters affecting both form and size produce marked changes in the VERs obtained from the six electrode sites. This would argue for a sensory rather than a perceptual interpretation of VER differences. There were many differences in experimental procedure between this and the John, Herrington and Sutton study. These include:

This Study	John, et al Study
1. all stimuli restricted to the macula	1. all stimuli peripheral to the macula

(*This Study*)	(*John, et al Study*)
2. stimulus presentation a sinusoidal change in contrast (101.6 ms duration)	2. stimulus presentation a square wave change in contrast (20 ms duration)
3. prestimulus background luminance 23.1 cd/m^2	3. prestimulus background luminance 0.0 cd/m^2
4. sinusoidal change in background luminance of 11.5% (peak) during stimulus presentation	4. square wave change in background luminance of 100% during stimulus presentation
5. background was $9^o32'$ x $9^o32'$	5. background size was virtually the whole visual field
6. random presentation of stimuli	6. repeated presentation of the same stimulus
7. random interstimulus interval (mean time = 15.5 ms)	7. constant interstimulus interval (time = 480 ms)
8. random presentation of 5 stimuli during recording session--32 recorded presentations per stimulus per session	8. 1 stimulus repeated 25 or 50 times per block--2 stimuli presented during 4 blocks per session--blocks arranged in 2 x 2 Latin-square
9. days to weeks between stimulus replications	9. stimuli replicated during same recording session
10. line stimuli equated for line width and perimeter	10. line stimuli equated for area of entire figure

A number of criticisms can be directed at the John, Herrington and Sutton (1967) study. Solutions of some of these criticisms would have strengthened their conclusions. Some of the criticisms shed doubt on their conclusions. The brief review of these criticisms that follows will include references that were and were not available in 1967. John, Herrington and Sutton did not

include figures stimulating the central 2 degrees of retina (1), which is the major area contributing to the VER and involved with sharp image resolution (Copenhaver and Perry, 1964; Perry and Copenhaver, 1965; Potts and Nagaya, 1965; Rietveld, Tordoir and Duyff, 1965; Rietveld, Tordoir, Hagenouw and Van Dongen, 1965; Spehlmann, 1965; Armington, 1966; Perry and Copenhaver, 1966; Armington, 1968; DeVoe, Ripps and Vaughan, 1968; Harter and White, 1968; Harter, 1970; Mildot and Riggs, 1970; White and Bonelli, 1970; Dawson, Perry and Childers, 1972; Wooten, 1972; Regan, 1973; Oguchi and van Lith, 1974; Osaka and Yamamoto, 1978). The central stimulation of the retina by the flash and the peripheral stimulation of the retina by the figure contours would have reduced figure contributions to the VER relative to flash contributions. This would have made any figure effects on the VER much more difficult to isolate.

A second criticism is that no use was made of a preadapting field or background (3). This produced some instability in dark (light) adaptation that would, to some extent, have been proportional to the number of flashes presented to obtain each VER (Perry and Copenhaver, 1964; Perry and Childers, pp. 40-46, 1969; Klingman, 1976). Regan (p. 40, 1972) has stated, "It is easy to see at once how the absolute intensity change is not the sole or even the major determinant of the EP....the common practice of using only very high percentage changes of brightness can bring with it not only difficulties in interpretation but may also result in the swamping of significant changes in EP features, due to effects of saturation."

A third criticism is that combining a flash, involving a high percentage change in luminance, with the presentation of dark line figures unnecessarily confounds these two stimuli (4). Although the flash maximum was of low absolute luminance, and the resulting VER probably not saturated, the flash itself was the major contributor to the VER, making any VER differences resulting from the figures relatively small. Confounding the flash with the figure presentation was compounded by using a flash stimulting the entire retina (5). This added several complicating factors to the interpretation. Ganzfeld effects (the subject was stimulated by illumination of a blank wall, except for the figure) and short intervals of darkness between flashes without a continuing fixation point can result in fluctuating states of accomodation and eye movements (Avant, 1965). That eye movements (scanning, pursuit, convergence or divergence, saccadic) and accomodative changes (blur), particularly for patterned stimuli, can affect the VER has been well established (Ratliff and Riggs, 1950; Riggs and Armington, 1954; Latour, 1962; Gaarder, Krauskopf, Kropf and Armington, 1964; Spehlmann, 1965; Gross, Vaughan and Valenstein, 1967; Michael and Stark, 1967; Scott and Bickford, 1967; Barlow and Ciganek, 1968; Bizzi, 1968; Duffy and Lombrosco, 1968; Harter and White, 1968; Wurtz, 1968; Wurtz, 1969; Wurtz, 1969a; Bizzi and Schiller, 1970; Harter and Salmon, 1971; Harter and White, 1970; Kurtzberg and Vaughan, 1970; Lesevre and Remond, 1973; Vaughan, 1973; Dawson, Perry and Childers, 1972; Ebersole and Galambos, 1973; Haddard and Steinman, 1973; Straschill and Schick, 1974). In

general, blur of patterned stimuli tends to reduce VER amplitudes. Eye movements, depending on the kind, can reduce or increase VER component amplitudes and latencies.

A fourth criticism is the use of repeated presentation of the same stimulus, particularly with a 480 ms interstimulus interval (6, 7). This can produce habituation effects on the VER (Bogacz, Vanzulli, Handler and Garcia-Austt, 1960; Garcia-Austt, Vanzulli, Bogacz and Rodriguez-Barrios, 1963; Walter, 1967; Perry and Copenhaver, 1965; Perry and Childers, pp. 55-58, 1969; Kitajima, 1978). In general, habituation effects are reflected in the VER as reduced amplitudes. However, the effects are not simple: occipital scalp recordings may reflect habitutaiton due to volume conductance from other brain areas; the effects of habituation may wax and wane over time; habituation is sensitive to interstimulus interval. In addition, the duration of the transient VER is often greater than 480 ms (Donchin, Wicke and Lindsley, 1963; Ciganek, 1964; Donchin and Lindsley, 1965; Donchin, 1966; Donchin, 1967). The interstimulus interval is critical due to effects of stimulus masking, cortical excitability or recovery cycle, and complex interaction of later with earlier VER components. This does not seem to be a particularly great problem with intervals longer than 1 second.

A fifth area of criticism has to do with use of a constant interstimulus interval and repeated presentation of the same stimulus (7, 8). To avoid inadvertant, time locked variables that may influence the VER and the effects of habituation, expecta-

tion and reduced attention, it has become standard practice to use a random interstimulus interval and when possible, to present stimuli in a random order (Donchin, 1966; Sutton, 1969; Desmedt, 1977; Donchin, 1977).

A sixth criticism is in regard to how John, Herrington and Sutton equated their figures--for total area (10). This meant that the proportion of dark line figure contour area to the bright figure center for the circle was somewhat smaller than for the square and diamond of the same total area. It is also worth noting that the perimeter of the circle was somewhat shorter than for the square and diamond, a feature known to affect the firing rate of cortical neurons that is independent of figure shape. Another characteristic of John, Herrington and Sutton's geometrical figures that was related, but did not determine figure shape, was the presence or absence of oblique lines (square versus diamond--and it may be that a circle is a special, extreme case of a figure with oblique lines). These features are also known to affect the firing rate of neurons in the visual cortex and the VER (Hubel and Wiesel, 1962; Hubel and Wiesel, 1963; Hubel and Wiesel, 1965; Enroth-Cugell and Robson, 1966; Campbell and Kulikowski, 1966; Campbell, Kulikowski and Levinson, 1966; Andrews, 1967; Hubel and Wiesel, 1968; Campbell and Maffei, 1970; Campbell, Cooper and Enroth-Cugell, 1969; Campbell, Cooper, Robson and Sachs, 1969).

Many of the reservations resulting from experimental procedure that one must necessarily have regarding the conclusions drawn in

the John, Herrington and Sutton (1967) study were largely overcome in this study. However, conclusions based on the geometrical figure data in this study are diametrically opposed to theirs. But if one could argue that John, Herrington and Sutton's conclusions would have remained the same with better experimental procedures, two particularly interesting differences between their study and this one may have accounted for the dissimilarity in results. It was stated by John, Herrington and Sutton (1967) and Garcia-Austt, Buno and Vanzulli (1971) that higher order "perceptual" effects represented in the VER are not robust, tending with many subjects to diminish or disappear with stimulus repetition and often with replication. This would imply that differences in form perception of simple geometrical figure shapes are represented in the VER, but for one of several possible reasons the VER is vulnerable. This could be because the brain processes associated with form perception or generating the VER are severely influenced or modified by stimulus repetition and time between replications. Or it could be that other brain processes represented in the VER increase representation in the VER as a consequence of stimulus repetition, hiding small differences resulting from the geometrical figures. Or it may be argued that long inter session intervals result in so much VER variability that figure effects are lost in the "noise." If VER correlates of form perception are very vulnerable to stimulus repetition, and they exist, one might wonder why John, Herrington and Sutton presented their stimuli the way they did, using repeated

stimulus presentation with a small interstimulus interval. One might also wonder why other experimental procedures were used that almost guaranteed a poor signal-to-noise ratio regarding figure effects in the VER. Every effort was made to reduce or eliminate these problems in the experimental procedures used in this study and John, Herrigton and Sutton's conclusions were not confirmed. The possibility that differences in time between replications and sessions could account for the differences between the conclusions in this and the John, Herrington and Sutton study remains. However, the likelihood that this is a major factor is reduced by the finding in this study that the differences between VERs resulting from angular subtense were as great as from shape. Evidence in this study would suggest that intervals of time between replications in the range of days to months have minimal effect on VER variability, although this does not mean that sizable differences in variability do not exist between VERs replicated minutes apart and those replicated a day or more apart. A second possible explanation for the differences in conclusions between this and the John, Herrington and Sutton study (1967) had to do with temporal factors in stimulus presentation. John, Herrington and Sutton used a 20 ms square wave pulse while a 101.6 ms sinusoidal pulse was used in this study. This difference in presentation was combined with differences in the retinal location of stimulation. These two considerations suggest a considerable difference in the stimulation of the transient and sustained channels by the two presenta-

tion procedures.* Breitmeyer (1976), Weisstein and Harris (1974), Weisstein, Williams and Williams (1979), and Williams and Weisstein (1979) have argued that different information is carried in these two channels, producing differences in perception. A pilot study** carried out by this writer subsequent to the collection of the VER data would tend to confirm this view. Three naive and three sophisticated subjects were each presented bright line reversible figures (reversible wedge or reversible staircase). The subject's task was to determine the orientation of the figure on each presentation and indicate this by pressing one of two low pressure buttons. If an orientation could not be determined, a third button was pressed indicating ambiguous or indeterminant. The same

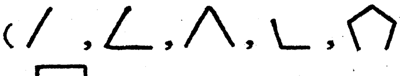
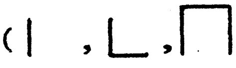
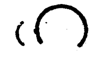
*The pulses in both presentations combine all the Fourier frequency components, but with proportionately different amplitudes--the square wave pulse being a more effective stimulus for transient channels, the sinusoidal pulse a more effective stimulus for sustained channels. The concentration of sustained neural pathways is greatest in the macular area, decreasing in concentration as one moves from central to peripheral retina. The concentration of transient pathways is greatest in the peripheral retina and least in central retina.

**The reversible figure was on a 35 mm Kodalith negative, mounted on a Tektronix oscilloscope screen that was masked except for the transparent lines of the figure. The reversible figure was back illuminated by either a square or sine wave pulse on the screen. The order and pulse shape were controlled by external logic. The luminance of the pulse was 4 cd/m^2 maximum, 0 cd/m^2 minimum. The screen and slide were viewed through a beam splitter so that a very dim fixation point could be continuously superimposed on the oscilloscope screen. The fixation point was in a tube, allowing it to be seen binocularly over a very small solid angle. Each stimulus presentation was initiated by the subject pressing a thumb activated button with a built-in 0.7 second delay. Viewing distance was 100 cm. Each subject was held in position by a chin rest. Stimuli were all viewed binocularly. Each subject was dark adapted 10 minutes preceding each session.

figure was randomly presented as a square or sine wave pulse, about 50 times each, during a session. The duration x luminance of the square and sine wave pulses were equated in any one session. There were five sessions with each subject during which the square wave pulse had one of five durations: 150 ms, 100 ms, 50 ms, 20 ms, 10 ms. Each subject was presented all durations over the five sessions with a different order of durations - sessions for each subject. There was no significant difference between the proportion of ambiguous responses for the sine and square wave presentations at durations 150 and 100 ms. The proportion of ambiguous responses for the sine wave presentations at 50 ms was much greater than for the square wave presentations. Almost all ambiguous presentations at 20 ms were for sine wave presentations. At 10 ms, the proportion of ambiguous responses was greater for the sine than for the square wave presentations, the size of the difference being greater than for 50 ms, but less than that for 20 ms. A tentative conclusion based on these pilot results was that the function used for temporal presentation of these figures differentially activates the sustained and transient channels, affecting the perceptual organization of these two reversible figures. The organization affected, in this case, may have been one of three dimensionality or related to some process determining figure orientation.

Based on the above discussion of differences between this and the John, Herrington and Sutton study, it is evident that the question regarding visual form perception effects on the VER is

not resolved. What has been shown is the need for two well controlled VER studies that investigate two variables and their possible effects on form perception of simple two dimensional geometrical figures and the VER: (1) time between VER replications; and (2) the temporal function and duration used in stimulus presentation.

VER data was obtained in this study from stimulus features including oblique lines (), horizontal and vertical lines (), and curved lines (). Conclusions resulting from analysis of these data will be the subject of a subsequent report. However, it should be mentioned here that no systematic relation was found between any of these features and the number of subjects showing a difference between figures, frequency components indicating a difference between figures, or electrode sites at which differences between figures were found. One possible exception to this was the difference between VERs resulting from the small square and small circle. Every subject showed a difference between these two figures at every electrode site but one, subject K at electrode site O_2. However, this result was not confirmed with the corresponding large figures.

The second part of this study, comparing meaningful and nonsense trigrams using the same letter elements, was also based on the John, Herrington and Sutton (1967) study. They found that different geometrical figure names equated for total area produced different VERs. I found that changing the order of letter elements also produced distinctly different VERs. These results

indicate that differences in the letter elements as well as order of letter elements in a stimulus affect the VER form. By themselves these two results would argue in favor of a sensory rather than meaning influence on the VER, again contradicting John, Herrington and Sutton's conclusions. However, the issue does not appear to be as simple as this. Although no difference between degree of difference was found between two meaningful trigram VERs, two nonsense trigram VERs, and meaningful and nonsense trigram VERs using the waveform analysis, a difference was found between components of the meaningful and nonsense composite VERs. This complicates the picture by suggesting a general effect on the VER based on differences in word class. A number of other investigators, recording both visual and auditory evoked potentials (VER and AEP respectively), have found similar class results. Brown, Marsh and Smith (1973, 1976) found differences in AEPs when the same ambiguous word was used in different contexts, one where the word was interpreted as a noun and the other where it was interpreted as a verb. Their results were confirmed by Teyler, Roemer, Harrison and Thompson (1973) and Roemer and Teyler (1977). These researchers have found that these differences are mainly reflected as hemispheric differences in the VER, particularly with respect to electrode sites F_7 and F_8. (F_7 is over Broca's area, a major speech area related to motor activity, and F_8 over the homologous area in the right hemisphere.) Shelburne (1972), on the other hand, found no hemispheric or other differences between VERs resulting from mean-

ingful or nonsense trigrams presented in an information delivery paradigm (keying on the presentation of the last letter of 3-letter sequences). Buchsbaum and Fedio (1969) found VER differences associated with the class of 3-letter words and the class of non-words. These VER differences were greater for the left than for the right hemispheres.

The conclusion that must be drawn from all these studies, including this one, is that specific meaning of word stimuli is not reflected in the VER, or their effects are so small that they cannot be resolved in the VER. Sensory effects like word order, letters in a word, etc. seem to be the primary factors reflected in the VER. More general responses to meaning may show up in the VER in the form of meaningful versus nonsense word classes, noun versus verb classes, and word versus geometrical shape classes. A replication of this study involving the unrepeated presentation of trigrams (as done by Buchsbaum and Fedio, 1969) investigating these class effects (part of speech, meaningfulness as defined by association value, meaningful versus nonsense words) as they relate to letter order and word area, would help clarify some of the issues.

The third part of this study investigated the effects of interpretation of reversible figures on the VER. The results left little doubt that different interpretations of a reversible figure do indeed produce distinctly different VERs. Based on the waveform analysis, differences in interpretation of a reversible

figure did not produce quite so great or reliable a difference in VERs as did differences in figure orientation or the addition or subtraction of figure lines. But the interpretation effects were strong and reliable. This result would confirm the findings of Garcia-Austt, Buno, and Vanzulli (1971). Given the improvement in the experimental design of this over their study it may fairly be concluded that these VERs do reflect a perceptual interpretation rather than a sensory difference.

In addition to the central conclusion that VERs reflect perceptual differences associated with reversible figure interpretation, two other related considerations need to be discussed. A comparison of the 2-dimensional geometrical figure composite VERs with the 3-dimensional reversible figure composite VERs at electrode sites O_1 and O_2 revealed an early positive component (peaking approximately 150 ms past record onset) that differentiated the two. This component also differentiated the reversible figure from the trigram composite VERs. Although these data cannot be conclusive, it looked as though this component interacted with a second, later positive component (peaking at approximately 175 ms past record onset). The second component appeared to be suppressed in amplitude by the first, the degree of suppression being directly related to the amplitude of the first component. This would confirm the finding in the Garcia-Austt, Buno and Vanzulli (1971) study that very early components were involved in differentiating interpretations of a reversible figure. The pos-

sibility exists that changes in this component may be related to the degree that a figure "appears" three dimensional or requires a three dimensional organization of sensory input, a perceptual variable. Weisstein (personal communication, 1979) has rated figures on three dimensionality and shown a reliable shift in metacontrast troughs with increasing three dimensionality. It is also possible that these early differences between the reversible figure VERs and the others is a consequence of small differences in experimental procedure related to their acquisition (requirement of a subject response and decision versus no requirement of a subject response or decision, respectively). This proposition should be tested in a well controlled VER study using figures rated for three dimensionality that does not require a subject response. A second consideration is the optimization of presentation procedures that would enhance perceptual influences on reversible figure VERs. A study investigating the effects of wave shape and duration of the presentation pulse on VERs obtained from reversible figures could be of considerable value. If transient and sustained channels do carry different visual information to cortex and are differentially involved in perceptual processes, it may well be that three dimensional organization of two dimensional images and interpretation of reversible figures will be influenced by different activation of these two pathways.

SUMMARY

This was an exploratory study using several strategies to determine whether or not form perception and stimulus meaning are reflected in the VER. A secondary purpose was to provide an experimental framework from which future, narrower studies might be fashioned to investigate variables influencing possible VER correlates of form perception and stimulus meaning. Part B of this study, based on results obtained by John Herrington and Sutton (1967), tested the proposition that geometrical figures of the same perimeter, but different shape would produce VERs that were different, but that geometrical figures of the same shape but different angular subtense would produce VERs that were the same or similar. Based on John, Herrington and Sutton (1967), the conclusion to be drawn from affirmation of this proposition would be that perceptual rather than sensory processes accounted for the results. The conclusions drawn from this part of this study were:

1. Differences between VERs resulting from geometrical figures are due to sensory rather than perceptual processes, directly contradicting the conclusions drawn by John, Herrington and Sutton (1967).
    a. Different geometrical figure forms with the same perimeter produce distinctly different VERs.
    b. Geometrical figures with the same form, but having different angular subtense produce distinctly different VERs.

2. Differences between the geometrical figure results obtained from this study and those obtained from the John, Herrington and Sutton (1967) study probably resulted from one or a combination of three causes:
   a. inadequate experimental procedures in the John, Herrington and Sutton study
   b. differences in the temporal aspects of stimulus presentation in the two studies
   c. differences in the time between stimulus replications in the two studies.
3. Two future studies are needed to investigate two variables and their possible effects on form perception of simple two dimensional geometrical figures and the VER:
   a. time between VER replications
   b. the temporal function and duration used in stimulus presentation.

Part C of this study was also based on results obtained by John, Herrington and Sutton (1967). The proposition tested was that meaningful trigrams would be more different from each other and from nonsense trigrams, than nonsense trigrams would be from each other. All trigrams compared were made up of the same two consonants and the same vowel. Only order of the letter elements was changed. A tentative conclusion that could be drawn from such a finding is

that the VER reflects differences in word meaning as well as, or instead of differences in the sensory response to letter shape and order. Conclusions drawn were:

1. Differences between VERs resulting from specific trigrams with different orders of letter elements resulted from "order" effects and not word meaning.
    a. No differences in degree of difference was found between VER comparisons of two meaningful trigrams, two nonsense trigrams, or a nonsense trigram with a meaningful trigram.
2. A possible general correlation between VER and word meaning can be shown.
    a. A difference was found between composite VER components of meaningful and nonsense trigrams.
3. A future VER study is needed to investigate word meaning classes as they relate to stimulus variables:
    a. parts of speech; meaningful versus nonsense words; word meaningfulness (defined by association value)
    b. letter order, word area, and letter elements.

Part D of this study investigated the effects of reversible figure interpretation on the VER. It was contended that distinctly different VERs resulting from different interpretations of the same figure could only be interpreted as a consequence of

perceptual rather than sensory processes. The conclusions drawn from this part of this study were:

1. Differences were found between VERs resulting from different interpretations of the same reversible figure. These differences were the result of perceptual rather than sensory processes.
2. Perceptual processes affecting the VER are small compared to sensory processes.
    a. Solid figures with an unambiguous orientation produced distinctly different VERs.
        (1) This could have been the consequence of a different number of figure lines or figure orientation.
    b. Solid figures with unambiguous orientation produced VERs that were distinctly different from those produced by the corresponding reversible figure.
        (1) This could have been the consequence of additional lines in the reversible figures or a consequence of different neural processing associated with the two types of figures.
3. A future study is needed to determine the effects on the VER of temporal function and duration used in presentation of reversible figures. This is

particularly important in attempting to optimize perceptual effects on reversible figure VERs.

Additional data was collected in this study to determine the effects of oblique lines, horizontal and vertical lines and curved lines on simple geometrical figures. Due to the use of six electrode positions (F_7, F_8, P_3, P_4, O_1 and O_2), hemispheric effects of all stimuli can also be determined. These results will be reported in a subsequent paper.

APPENDIX A

Data Analysis

LEVEL ONE ANALYSIS

The logic of the VER analysis used in this study is derived from definitions of "wave" and "form." At base "form" is a relativistic concept defined by the "drawing of a distinction" (G. Spencer Brown, 1972). Two VERs derived from different stimuli are distinct if they are more different from each other than replications of either stimulus. Replicated VERs (i.e., VERs derived from the same subject, same stimulus, same electrode site, same recording conditions, but recorded during different sessions) are considered the same except for error.

A "wave" is defined as a series of simple cosine functions,

$$Y = \sum_{k=0}^{k=29} A_k \cos(k\theta - \phi_k)$$

defined over the interval $0 \leq \theta < 2\pi$ and $0 \leq \phi < 2\pi$. A_k is the amplitude, ϕ_k the phase angle, and k a positive integer or 0 representing the frequency of the cosine function with respect to the defined interval.

All VERs in this study were replicated under one of three conditions:

1. 12 geometrical figures, 8 trigrams, 4 geometrical figure names, and 6 geometrical figure features formed a pool of 30 stimuli. Stimuli were randomly selected from the pool, 5 at a time without replacement, and presented, 5 per session for 6 sessions. This procedure was then replicated using

a second random selection of stimuli from the same pool.

2. 2 solid figures and 2 reversible figures (each with 2 interpretations) were all presented in each of 8 sessions.

3. 1 blank stimulus (no stimulus), 1 background only stimulus, 1 geometrical figure feature stimulus, 1 flash stimulus and 1 offset stimulus were all presented in each of 4 sessions spaced throughout the experiment.

Amplitude and phase differences were computed for 29 frequencies for each replication: for 30 stimuli in group 1; for 6 stimulus interpretations in group 2 based on data combined from the first, third, fifth and seventh sessions and data combined from the second, fourth, sixth and eighth sessions; and for four of the five stimuli in group 3 (blank, background only, figure feature and flash). Group 3 had three replications providing VER amplitude and phase differences based on the first and third sessions and on the second and fourth sessions. The amplitude differences based on replications formed error distributions that are summarized in Appendix B.

Differences between VERs derived from different stimuli can be established in one of two ways. Confidence intervals can be established based on empirically determined error distributions, or such differences can be determined only with respect to replications of VERs comprising the difference. The second procedure was chosen in anticipation of improved sensitivity. VERs tend to

show considerable variability under the best of conditions. A relatively few "deviant" VERs can inflate the error distributions masking subtle differences that actually exist.

The procedure that was adopted took the following form:

1. All VERs replicated using procedures in groups 1 and 3 were based on an average from 32 stimulus presentations per session ($\overline{\Sigma 32}$). VERs replicated using group 2 procedures were based on an average of 8 stimulus presentations per session (VERs from 4 sessions were then averaged to form a $\overline{\Sigma 32}$ VER).
2. Each $\overline{\Sigma 32}$ VER was digitally filtered by doing a Fourier transform of the data, setting all amplitude and phase components at frequencies greater than 29 Hz to 0, and doing an inverse Fourier transform.
3. Amplitude and phase differences were determined at each frequency for each replicated, digitally filtered $\overline{\Sigma 32}$ (DF$\overline{\Sigma 32}$) VER (0-29 Hz).
4. The mean of each DF$\overline{\Sigma 32}$ VER and each replicated DF$\overline{\Sigma 32}$ VER was determined, producing a DF$\overline{\Sigma 64}$ VER for each stimulus.
5. A Fourier transform of each DF$\overline{\Sigma 64}$ VER was obtained and amplitude and phase differences between VERs from different stimuli to be compared were computed (at each frequency, 1-29 Hz).
6. Two DF$\overline{\Sigma 64}$ VERs derived from different stimuli were to be considered of different waveform (distinct) if one or more frequency components showed a difference in amplitude greater

than that of both replications (frequencies 1-29 Hz).

Fourier Analysis

Fourier analysis involves the fitting by least squares of sinusoidal curves of different frequencies to a set of data. Thus, the method is equivalent to multiple regression with trigonometric transformations of the independent variable (Rayner, 1971). The consequence of this procedure is the transformation of the data to a series of simple, weighted sine or cosine functions of different frequency and phase. Transformed data is often presented as a frequency spectrum, relating frequency and amplitude, or frequency to percent total variance or power. The spectrum associated with periodic data is a discrete spectrum, whereas the spectrum associated with non-periodic data is continuous. The purpose of this procedure in this study is to determine a unique algebraic description of each VER.

"Almost any function of a real variable could be represented as the sum of sines and cosines."

1. Given: a cosine function defined over the interval

$$0 \leq \theta < 2\pi \text{ and } 0 \leq \phi < 2\pi \ldots$$

$$Y = A_k \cos (k\theta - \phi_k)$$

where Y is the ordinate and θ is the abscissa. A_k is the amplitude, ϕ_k is the phase angle, and k is a positive integer or 0 representing the frequency of the cosine function with respect to the defined interval.

If: $\cos(R - S) = \cos S \cos R + \sin S \sin R$

Then: $Y = A_k \cos(\phi_k) \cos(k\theta) + A_k \sin(\phi_k) \sin(k\theta)$

2. Define: $a_k = A_k \cos(\phi_k)$ and

$b_k = A_k \sin(\phi_k)$

Then: $Y = A_k \cos(k\theta - \phi_k) = a_k \cos(k\theta) + b_k \sin(k\theta)$

Since: $\cos^2 S + \sin^2 S = 1$

Then: $A_k = (a_k^2 + b_k^2)^{1/2}$ for the cosine function

And: $\phi_k = \arctan\left(\frac{b_k}{a_k}\right)$

"The signs of a_k and b_k give the quadrant in which ϕ_k appears."

And: $A_k \sin(k\theta + \phi_k) = a_k \cos(k\theta) + b_k \sin(k\theta)$

Then: $\phi_k = \arctan\left(\frac{a_k}{b_k}\right)$ for the sin function

The sum of functions described above form Fourier series:

$$x_\theta = \sum_{k=0}^{\infty} A_k \cos(k\theta - \phi_k)$$

$$= \sum_{k=0}^{\infty} [a_k \cos(k\theta) + b_k \sin(k\theta)]$$

$$= a_0 \cos 0 + a_1 \cos\theta + \ldots + a_k \cos(k\theta) + \ldots + b_0 \sin 0 +$$

$$b_1 \sin\theta + \ldots + b_k \sin(k\theta) + \ldots$$

"...Fourier analysis is the process of fitting Fourier series to data and of calculating A_k and ϕ_k, the amplitudes and phase angles, of the various waves... ...Thus a complicated function is reduced to a series of simple functions, sinusoidal waves."

3. Given: A function $x(t)$

Such That: (1) $x(t)$ is single valued and finite

(2) $x(t)$ is defined for every point in the basic interval

(3) $x(t)$ has a finite number of maxima, minima, and discontinuities in the basic interval

(4) $x(t)$, as defined within the intervals, repeats itself completely to $-\infty$ and to ∞. It is, then, periodic.

"The fitting method used is that of least squares, but, because of the orthogonality of trigonometric functions, this technique is greatly simplified..."

"Since the function $x(t)$ is frequently represented by a series of discrete points (observations), the resulting Fourier series will depict the points and not necessarily the function $x(t)$. The closeness of fit between points and, therefore, the usefulness of the Fourier series for interpolation will depend on the actual frequencies present in $x(t)$ and those calculable from the discrete points."

4. Given: for $x(t)$, t varies between 0 and T

Therefore: $\theta = 2\pi r/T$ radians

And: for n equally spaced observations over the basic interval 2π, the spacing between observations is given by

$\Delta\theta = 2\pi/n$ radians

And: any particular observation may be denoted by the subscript j, where j is an integer varying between 0 and n-1

Then: $\theta_j = \theta_0 + j\Delta\theta = \theta_0 + j\,\frac{2\pi}{n}$ for the $(j + 1)^{th}$ point along the abscissa

Or: $\theta_j = \frac{2\pi j}{n}$ radians for $\theta_0 = 0$

And: for $t = t_j = j\Delta t$ and $T = n\Delta t$

$\theta_j = \frac{2\pi\ t}{n\Delta\ t}$ radians

And: $\Delta t \to 0$ as $n \to \infty$

Similarly: to convert phase shift to units of t

Distance of the first maximum from the origins in units of $t = \frac{\phi_k}{k} \times \frac{n\Delta t}{2\pi}$

Now: $x(t) = \sum_{k=0}^{\infty} A_k \cos(\frac{2\pi kt}{T} - \phi_k)$

for continuous data

"Since at least two points are needed to specify a sinusoidal curve, the maximum frequency k_{max} calculable from equi-spaced data is n/2, where n is even, or (n - 1)/2, where n is odd."

And: $x(j) = \sum_{k=0}^{n/2 \ \underline{or}\ (n-1)/2} A_k \cos(\frac{2\pi kj}{n} - \phi_k)$

for discrete data

"Calculation of coefficients for $k > k_{max}$ will show that they are periodic: the a's are symmetric and the b's asymmetric about $k = 0$ and $k = k_{max}$."

5. It may be shown that to calculate the coefficients

$$\frac{2}{T} \int_0^T x(t) \cos \left(\frac{2\pi kt}{T}\right) dt = a_k$$

OR

$$a_k = \frac{2}{n} \sum_{j=0}^{n-1} x(j) \cos \left(\frac{2\pi jk}{n}\right)$$

And: $$b_k = \frac{2}{n} \sum_{j=0}^{n-1} x(j) \sin \left(\frac{2\pi jk}{n}\right)$$

And: $$\tilde{a}_0 = \frac{1}{n} \sum_{j=0}^{n-1} x(j)$$

And: for n even

$$\tilde{a}_{n/2} = \frac{1}{n} \sum_{j=0}^{n-1} x(j) (-1)^j$$

"There is no $b_{n/2}$. It can be seen that $\tilde{a}_0$ is, in fact, the mean of the function x(t). In order to make this coefficient comparable with the others, the mean is frequently defined as being equal to 1/2 a_0. Then

$$a_0 = \frac{2}{n} \sum_{j=0}^{n-1} x(j) \cos \left(\frac{2\pi j0}{n}\right) \ldots$$

Similarly $a_{n/2}$ may be set equal to $1/2a_{n/2}$ and

$$a_{n/2} = \frac{2}{n} \sum_{j=0}^{n-1} x(j) \cos \left(\frac{2\pi \frac{n}{2} j}{n}\right) \ldots$$

which is the same as described above with k = n/2.

And: $A_0 = \tilde{a}_0$ and $A_{n/2} = \tilde{a}_{n/2}$

A variance spectrum may be plotted following Fourier analysis by using the following relationship:

$$\text{Contribution:} \quad (\%) = \frac{A_k^2 \times 100}{\sum_{k=1}^{n/2} A_k^2}$$

The fast Fourier transform introduced by Cooley and Tukey in 1965, along with the advent of digital computers, has revolutionized the application of Fourier analysis. Although Cooley and Tukey were not the first to recognize this procedure, they were the first to gain a wide readership.

The fast Fourier transform algorithm simply reduced the number of calculations from a number proportional to n^2 to a number approximately proportional to n log n. This procedure, now routinely used in calculating coefficients will be used in this study.

LEVEL TWO ANALYSIS

Level one of the analysis procedure describes how single comparisons between VERs were obtained. It is a within subjects analysis dealing only with one question... "Are VERs obtained from the same subject, but derived from different stimuli of different waveform?" The level one analysis does not ask or answer questions regarding what magnitude of difference might constitute a meaningful difference, or how patterns of difference might relate to stimulus parameters, or what differences might exist at different electrode sites, or how different subjects' responses might compare.

In order to look at these questions, binary arrays were developed showing patterns of differences for different stimuli across electrode sites and across subjects. Placement of differences in these binary arrays was based directly on the comparisons from the level one analysis. Interpretation of the binary arrays must depend on choice of stimuli, experimental procedures and extra-experimental information.

APPENDIX B

Error Distributions

Tables B-1 through B-18 show Fourier frequency component amplitude differences (in microvolts) between replicated $\overline{\Sigma 32}$ control VERs at each of 29 frequencies (in Hertz) obtained during four control sessions. Each table gives results from three subjects (K, JI and JU) at one of six electrode sites (F_7, F_8, P_3, P_4, O_1 or O_2). Each difference was obtained from $\overline{\Sigma 32}$ VERs resulting from the same control stimulus presented during the first and third control sessions (1) or the second and fourth control sessions (2):

1	2
Subject K	Subject K
8/21/77	8/22/77
10/29/77	7/17/78
Subject JI	Subject JI
10/30/77	11/19/77
1/11/78	7/17/78
Subject JU	Subject JU
10/29/77	10/30/77
7/15/78	10/08/78

The control VERs compared were:

1. Blank--no background and no figure
2. Background Only--background, but no figure
3. Figure--background and a partial circle, open at the base for subjects K and JU, and the corners of a square for subject JI.

The bar graphs following Table B-18 show distributions of

Fourier frequency component amplitude differences between 36 replicated $\overline{\Sigma 32}$ VERs (error distributions). A separate distribution is given for each subject at each electrode site for each Fourier frequency component between 1 and 29 Hz. The frequency component is given at the upper right of each graph. Each abscissa represents the difference in amplitude of a designated Fourier frequency component between a $\overline{\Sigma 32}$ VER and its replication (given in microvolts). The ordinate represents the number of each difference recorded (count). The black bars represent frequency amplitude difference counts from 30 stimuli and their 30 corresponding replications (4 small geometrical figures, 4 large geometrical figures, 10 geometrical figure features, 4 meaningful trigrams, 4 nonsense trigrams). The white bars represent frequency amplitude difference counts from 6 stimulus conditions and their 6 corresponding replications (2 solid wedges, 2 reversible wedge interpretations, 2 reversible staircase interpretations). The white bars are superimposed on the black bars. Bars at the left of the break in the abscissa (top four graphs on each page) represent counts of frequency component amplitude differences greater than $|1.2|$ μV.

TABLE B-1

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BLANK - BLANK

ELECTRODE POSITION F7

	K		JI		JU	
F	1	2	1	2	1	2
1	0.27	-0.64	0.01	0.02	0.14	-0.01
2	-0.36	-0.34	0.14	0.20	0.10	-0.24
3	-0.41	-0.26	-0.11	0.04	-0.13	0.15
4	0.13	0.10	0.37	-0.04	0.11	-0.12
5	0.21	0.15	0.19	-0.08	0.10	-0.01
6	0.56	-0.22	0.23	-0.21	0.09	0.16
7	0.16	-0.02	-0.11	0.33	0.02	0.00
8	-0.28	-0.52	0.08	0.11	0.16	0.08
9	0.34	-0.27	0.16	0.11	-0.14	-0.06
10	0.17	-0.11	-0.01	-0.03	0.13	0.32
11	-0.10	-0.07	-0.06	-0.06	-0.01	-0.06
12	0.17	-0.14	-0.18	0.18	0.24	-0.04
13	-0.06	-0.17	0.05	0.03	0.05	0.13
14	0.01	0.07	0.15	0.01	-0.02	-0.04
15	-0.01	0.03	-0.04	-0.11	-0.07	0.12
16	-0.03	-0.02	0.13	0.07	0.05	-0.07
17	-0.01	0.10	-0.01	0.17	-0.07	0.00
18	-0.03	0.02	-0.16	0.15	-0.06	0.01
19	-0.05	-0.05	0.05	-0.13	0.01	-0.10
20	0.08	-0.09	-0.16	0.10	-0.14	-0.22
21	-0.06	-0.02	-0.14	-0.12	-0.07	0.09
22	-0.07	0.01	0.23	0.03	-0.01	0.02
23	0.01	-0.00	0.08	-0.35	-0.01	-0.10
24	-0.00	-0.08	0.14	-0.05	-0.30	0.04
25	-0.00	-0.07	0.06	0.02	-0.14	0.10
26	-0.09	0.10	0.14	0.00	-0.03	-0.13
27	0.03	0.20	0.12	-0.12	-0.32	0.04
28	-0.06	-0.04	0.05	-0.20	-0.00	-0.18
29	-0.07	0.02	0.18	0.02	-0.03	-0.16

TABLE B-2

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BACKGROUND ONLY - BACKGROUND ONLY

ELECTRODE POSITION F7

	K		JI		JU	
F	1	2	1	2	1	2
1	0.27	-0.64	-0.29	-0.88	-0.95	-0.01
2	-0.36	-0.34	0.67	-0.16	-0.26	-0.03
3	-0.41	-0.26	0.10	-0.02	0.05	-0.05
4	0.13	0.10	0.14	0.05	-0.10	-0.22
5	0.21	0.15	0.08	-0.31	0.03	0.07
6	0.56	-0.22	0.15	0.12	-0.43	0.29
7	0.16	-0.22	0.04	0.13	-0.41	0.04
8	-0.28	-0.52	-0.19	-0.02	0.13	-0.06
9	0.34	-0.27	0.09	0.03	0.26	-0.40
10	0.17	-0.11	0.27	-0.14	-0.32	-0.22
11	-0.10	-0.07	0.16	-0.13	-0.06	0.05
12	0.17	-0.14	0.15	-0.21	0.12	0.01
13	-0.06	-0.17	0.13	0.10	-0.09	0.02
14	0.01	0.07	-0.03	-0.03	-0.09	-0.05
15	-0.01	0.03	0.16	-0.01	-0.03	0.12
16	-0.03	-0.02	-0.06	0.08	-0.20	-0.01
17	-0.01	0.10	-0.03	-0.05	0.03	-0.07
18	-0.03	0.02	0.08	0.01	-0.05	0.19
19	-0.05	-0.05	-0.09	-0.32	0.10	0.02
20	0.08	-0.09	0.08	0.00	0.04	-0.06
21	-0.06	-0.02	0.22	-0.08	-0.04	-0.08
22	-0.07	0.01	0.14	-0.06	-0.17	0.02
23	0.01	-0.00	0.14	0.04	0.11	-0.10
24	-0.00	-0.08	0.07	0.08	-0.20	0.23
25	-0.00	-0.07	-0.02	-0.18	-0.04	0.07
26	-0.09	0.10	-0.08	0.07	-0.05	0.13
27	0.03	0.20	0.03	0.01	-0.27	0.01
28	-0.06	-0.04	-0.02	0.06	0.10	-0.05
29	-0.07	0.02	0.01	-0.08	-0.15	-0.10

TABLE B-3

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS FIGURE FEATURE - FIGURE FEATURE

ELECTRODE POSITION F7

	K		JI		JU	
F	1	2	1	2	1	2
1	-0.33	-0.40	-1.49	-1.38	-1.69	-0.86
2	-0.87	0.25	-0.71	-0.83	0.14	0.33
3	-0.97	-0.53	-0.60	-0.44	-0.03	0.03
4	-0.15	-0.41	-0.06	-0.60	-0.03	-0.14
5	0.08	-0.71	-0.30	-0.14	-0.23	0.18
6	-0.23	-1.16	0.24	-0.45	0.12	0.16
7	0.39	-0.33	-0.06	-0.15	0.38	0.15
8	-0.45	0.52	0.18	-0.22	-0.07	-0.51
9	-0.25	-0.40	0.39	0.07	0.06	-0.22
10	-0.32	-0.60	0.12	-0.04	-0.25	0.06
11	-0.19	0.17	0.15	0.00	-0.06	-0.13
12	-0.11	0.14	0.09	0.01	-0.27	-0.07
13	0.01	-0.13	-0.09	-0.07	0.01	0.08
14	-0.15	0.08	0.12	-0.04	0.14	0.05
15	-0.11	-0.29	-0.07	0.23	0.25	-0.00
16	-0.05	0.23	-0.03	-0.02	-0.23	-0.10
17	-0.20	0.05	-0.02	0.17	-0.03	-0.03
18	0.00	0.17	0.16	0.02	-0.06	0.06
19	-0.09	0.15	-0.02	0.08	0.08	-0.07
20	-0.23	-0.01	0.29	0.13	-0.17	0.09
21	-0.11	0.16	0.04	-0.10	-0.09	-0.04
22	-0.01	0.07	0.24	-0.36	-0.25	0.01
23	0.01	-0.00	0.25	0.12	0.05	-0.13
24	-0.06	-0.13	0.16	0.29	-0.12	0.06
25	0.06	0.36	-0.06	0.01	-0.24	-0.11
26	-0.04	0.11	-0.07	-0.09	0.15	0.05
27	0.09	-0.12	0.05	0.15	-0.49	0.05
28	0.05	0.01	0.17	0.04	0.04	-0.03
29	0.01	-0.03	-0.03	0.09	0.12	0.05

TABLE B-4

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BLANK - BLANK

ELECTRODE POSITION F8

	K		JI		JU	
F	1	2	1	2	1	2
1	-0.12	0.41	-0.69	-0.82	0.57	0.19
2	-0.60	-0.20	-0.00	0.12		
3	-0.05	-0.28	-0.23	-0.19	0.28	-0.15
4	-0.07	0.06	0.01	-0.35	0.03	0.09
5	-0.01	-0.15	-0.28	0.31	0.18	-0.11
6	0.03	-0.12	-0.51	0.28	0.03	0.03
7	-0.02	0.12	0.05	0.03	-0.00	0.01
8	-0.02	-0.25	-0.04	0.10	0.09	-0.04
9	0.03	-0.03	0.01	0.12	-0.11	0.01
10	-0.15	0.19	0.08	0.09	0.07	0.93
11	-0.16	0.03	0.14	0.22	0.22	-0.06
12	0.03	-0.06	-0.02	0.16	0.03	0.05
13	0.07	-0.16	-0.15	-0.14	0.00	-0.16
14	-0.09	0.04	0.01	-0.14	-0.13	0.13
15	-0.11	-0.00	-0.16	0.09	-0.03	0.11
16	-0.09	-0.09	-0.04	0.08	0.05	-0.05
17	-0.06	0.21	-0.03	0.01	-0.17	-0.06
18	0.03	0.13	0.18	0.02	0.08	-0.11
19	-0.04	0.07	0.16	-0.08	0.06	0.00
20	0.01	0.08	0.02	-0.08	0.02	0.05
21	-0.06	0.08	0.36	-0.13	0.05	-0.08
22	-0.21	-0.06	0.26	0.07	-0.22	0.03
23	-0.12	-0.09	-0.16	-0.14	-0.03	-0.01
24	-0.09	-0.07	-0.12	-0.02	-0.02	0.07
25	0.06	-0.01	0.24	0.03	0.14	-0.10
26	0.06	0.03	-0.14	-0.03	0.37	-0.04
27	-0.00	0.02	0.07	0.42	-0.04	0.05
28	-0.08	0.07	0.04	0.04	-0.06	0.02
29	-0.11	0.01	0.06	0.00	0.23	0.25

TABLE B-5

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BACKGROUND ONLY - BACKGROUND ONLY

ELECTRODE POSITION F8

	K		JI		JU	
F	1	2	1	2	1	2
1	0.50	0.84	0.50	-0.82	1.35	0.19
2	-0.59	0.06	-0.07	0.15	-0.12	0.32
3	-0.33	0.30	0.18	-0.00	0.57	0.07
4	-0.04	0.32	0.05	-0.27	0.66	-0.16
5	-0.03	0.60	0.08	0.23	0.24	-0.10
6	-0.79	0.33	0.05	0.20	-0.02	0.35
7	-0.02	0.07	0.39	0.12	0.15	0.26
8	0.31	0.18	0.11	-0.20	-0.08	0.19
9	-0.32	0.13	-0.17	-0.17	0.04	-0.16
10	-0.04	0.02	-0.02	0.07	-0.28	-0.18
11	0.00	0.30	-0.15	-0.07	-0.13	-0.02
12	0.06	0.20	-0.16	0.11	0.21	0.11
13	0.03	0.00	-0.06	-0.02	-0.04	-0.08
14	-0.01	-0.05	0.16	0.16	-0.00	0.02
15	-0.16	0.00	0.04	-0.07	-0.10	-0.05
16	0.02	0.13	0.06	-0.10	-0.02	-0.02
17	0.06	0.17	0.03	0.20	0.30	0.13
18	-0.13	0.12	0.13	0.10	-0.05	-0.25
19	0.07	0.09	-0.24	0.14	0.01	-0.10
20	0.07	0.09	-0.02	0.18	0.01	-0.11
21	0.03	0.04	0.06	-0.01	0.16	0.07
22	0.04	0.09	0.04	0.08	-0.09	-0.06
23	0.09	0.03	-0.09	-0.05	0.07	0.06
24	-0.02	0.04	-0.54	-0.09	-0.01	0.15
25	-0.07	0.11	-0.21	0.12	0.18	-0.14
26	-0.04	-0.01	-0.18	0.08	0.10	0.07
27	0.07	-0.01	-0.07	0.20	0.08	-0.21
28	0.04	0.09	-0.05	-0.11	0.17	-0.04
29	-0.05	0.03	-0.04	0.02	0.04	-0.04

TABLE B-6

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS FIGURE FEATURE - FIGURE FEATURE

ELECTRODE POSITION F8

	K		JI		JU	
F	1	2	1	2	1	2
1	-0.17	0.33	0.63	-0.71	0.23	-2.45
2	-0.67	-0.31	-1.31	-1.29	-0.64	-0.59
3	-1.24	-0.19	-0.57	-1.05	-0.12	0.05
4	-0.09	-0.20	-0.01	-0.00	0.16	0.02
5	-0.01	-0.35	0.01	-0.48	-0.05	0.10
6	-0.57	-0.81	-0.31	0.08	0.26	-0.08
7	0.51	-0.05	0.10	-0.19	-0.04	-0.10
8	-0.33	0.19	-0.14	0.07	-0.16	-0.34
9	-0.05	-0.03	0.10	0.00	-0.20	-0.14
10	-0.10	-0.32	0.32	-0.06	-0.10	-0.18
11	0.08	0.46	-0.19	0.02	0.14	-0.26
12	0.06	0.17	-0.17	-0.05	0.01	0.01
13	0.09	-0.11	0.09	-0.05	0.13	-0.00
14	0.16	-0.02	0.31	-0.06	-0.15	0.15
15	0.05	0.04	0.11	-0.08	0.06	-0.05
16	-0.14	0.03	-0.06	0.06	0.01	-0.20
17	0.01	-0.02	0.10	-0.04	-0.04	0.44
18	-0.05	0.16	0.21	-0.01	-0.04	-0.09
19	-0.02	-0.01	0.23	-0.49	-0.14	0.14
20	0.02	0.12	-0.03	0.06	0.05	0.20
21	-0.06	0.06	0.04	-0.04	0.10	0.15
22	0.12	0.06	-0.31	-0.06	0.25	0.03
23	0.03	-0.07	-0.39	0.06	0.12	0.20
24	0.07	0.07	-0.17	-0.20	-0.10	-0.04
25	-0.09	-0.09	0.16	-0.12	0.07	-0.11
26	-0.14	0.17	-0.15	0.35	-0.02	0.10
27	-0.05	-0.02	0.06	0.03	-0.06	-0.02
28	-0.01	-0.03	0.05	-0.06	-0.11	0.17
29	-0.03	0.11	-0.07	-0.17	0.10	0.17

TABLE B-7

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BLANK - BLANK

ELECTRODE POSITION P3

	K		JI		JU	
F	1	2	1	2	1	2
1	0.17	0.28	0.49	-0.19	0.31	-0.07
2	-0.53	0.06	0.39	0.03	-0.14	0.06
3	-0.23	0.25	-0.01	0.08	0.17	-0.18
4	0.07	-0.36	0.19	-0.03	0.09	-0.02
5	0.18	-0.02	0.04	0.17	0.25	-0.05
6	0.16	0.10	-0.06	-0.01	-0.06	0.04
7	-0.03	0.10	-0.05	0.04	0.11	0.04
8	0.22	-0.14	-0.12	0.01	0.10	0.03
9	0.07	-0.31	-0.11	0.06	-0.05	0.01
10	0.52	-0.49	-0.07	0.04	0.04	0.31
11	-0.08	-0.47	-0.01	-0.07	0.20	0.26
12	-0.08	-0.14	-0.05	-0.20	-0.08	-0.08
13	-0.24	-0.29	0.03	0.01	0107	0.20
14	-0.05	-0.28	0.01	-0.17	0.20	-0.09
15	-0.13	0.04	-0.02	0.06	0.23	-0.05
16	-0.16	-0.01	0.05	0.11	0.13	0.05
17	0.03	-0.14	0.21	0.17	-0.11	-0.06
18	-0.09	-0.02	0.02	0.16	-0.01	-0.04
19	0.03	0.10	-0.03	-0.08	0.14	-0.01
20	0.10	0.13	0.19	-0.08	0.16	0.00
21	-0.03	0.09	-0.07	0.12	0.06	0.02
22	-0.07	0.10	0.01	0.06	0.04	0.06
23	0.02	0.05	-0.06	0.03	0.10	-0.10
24	-0.05	-0.08	-0.01	-0.02	-0.06	-0.03
25	-0.01	-0.03	0107	-0.02	-0.01	0.04
26	0.03	0.08	0.18	-0.08	0.08	0.03
27	0.12	0.18	0.05	0.04	0.06	-0.04
28	-0.13	0107	0.05	-0.04	-0.05	-0.10
29	-0.03	-0.04	-0.00	-0.03	0.05	0.02

TABLE B-8

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BACKGROUND ONLY - BACKGROUND ONLY

ELECTRODE POSITION P3

	K		JI		JU	
F	1	2	1	2	1	2
1	-0.49	-0.03	-0.01	-0.35	-0.16	-0.72
2	-0.03	-0.32	0.93	0.10	0.00	-0.02
3	-0.36	-0.22	0.02	-0.18	0.22	-0.30
4	-0.02	0.80	0.57	0133	0158	0.08
5	0.11	0.64	0.11	0.02	-0.06	-0.03
6	-0.56	0.48	0.18	0.38	-0.03	0.11
7	0.13	0.27	0.26	-0.02	-0.03	-0.05
8	-0.36	-0.22	0.22	0.29	0.08	-0.19
9	-0.03	-0.21	0.19	0.12	-0.18	0.04
10	-0.59	-0.36	0.21	0.33	-0.12	0.15
11	-0.25	0.13	0.13	0.10	0.56	0.01
12	0.08	0.31	0.14	-0.06	-0.11	0.11
13	-0.04	-0.10	0.07	-0.00	0.31	0.05
14	-0.15	-0.12	0.04	-0.10	0.30	-0.18
15	0.14	0.09	0.13	0.07	0.18	0.16
16	-0.06	-0.04	-0.14	0.08	-0.14	0.04
17	-0.06	0.11	-0.08	0.01	-0.08	-0.02
18	-0.06	0.10	0.10	0.26	-0.02	0.01
19	0.01	0.04	0.14	0.25	0.26	0.04
20	0.11	0.08	0.12	-0.13	0.16	0.13
21	0.08	0.01	-0.04	-0.22	-0.02	-0.02
22	0.09	0.09	-0.02	-0.07	-0.04	0.02
23	0.05	-0.10	0.01	0.11	-0.03	-0.01
24	0.03	0.00	0.05	0.10	0.18	0.04
25	0.03	0.04	-0.02	0.01	-0.01	-0.01
26	-0.02	0105	0.10	0.13	0.04	-0.03
27	-0.02	0.05	-0.04	-0.05	0.01	0103
28	-0.03	0.06	-0.04	-0.02	0.12	0.01
29	-0.08	0.10	0.06	0.00	0.02	0.05

TABLE B-9

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS FIGURE FEATURE - FIGURE FEATURE

ELECTRODE POSITION P3

F	K 1	K 2	JI 1	JI 2	JU 1	JU 2
1	-0.40	-0.55	-2.55	-1.60	-0.74	-0.76
2	-0.18	0.11	-0.09	-0.46	-0.95	-0.02
3	-0.12	-0.29	0.17	-0.24	0.13	-0.11
4	0.09	-0.08	0.12	-0.20	0.41	0.12
5	-0.02	-0.46	0.53	-0.18	0.83	-0.29
6	0.26	-0.10	0.26	0.45	-0.05	-0.14
7	-0.18	0.37	0.02	0.12	0.10	-0.10
8	-0.48	0.17	-0.49	0.02	-0.29	-0.33
9	0.01	0147	-0.02	0.38	-0.26	0.09
10	0.29	0.28	0.06	0.57	-0.27	-0.10
11	-0.14	0.17	-0.09	0.89	0.66	-0.00
12	0.13	-0.01	0.42	0.18	-0.02	0.20
13	-0.34	-0.06	0.04	0.12	0.18	0.04
14	-0.01	-0.19	-0.05	-0.05	0.03	-0.04
15	-0.05	-0.02	-0.06	-0.17	-0.08	-0.15
16	-0.17	0.07	0.00	-0.01	0.01	0.01
17	-0.06	0.08	0.16	-0.02	-0.03	-0.05
18	0.10	0.08	0.31	0.10	-0.12	0.06
19	-0.10	0.03	-0.11	0.18	-0.02	-0.00
20	0.02	0.04	0.14	0.17	0.03	0.06
21	-0.03	0.12	-0.09	0.03	-0.06	-0.02
22	-0.04	0.10	-0.05	0.01	-0.05	-0.02
23	0.13	0.11	0.03	0.13	0.13	0.07
24	-0.07	0.11	0.09	0.01	0.01	0.11
25	0.00	0.08	-0.04	0.04	0.17	-0.02
26	-0.09	0.20	-0.07	0.19	0.04	0.01
27	0108	0.08	0.04	0.02	0.06	0.04
28	-0.04	0.01	0.06	-0.03	-0.04	0.03
29	0.02	-0.06	-0.08	0.10	0.01	0.04

TABLE B-10

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BLANK - BLANK

ELECTRODE POSITION P4

	K		JI		JU	
F	1	2	1	2	1	2
1	0.34	0.85	0.08	-0.47	0.38	-0.07
2	-0.15	0.06	0.04	-0.03	0.27	0.37
3	-0.09	0.07	-0.04	-0.05	0.24	-0.04
4	-0.05	-0.09	0.22	0.07	0.14	0.02
5	0.06	0.22	0.11	-0.19	0.05	-0.00
6	-0.29	-0.19	-0.30	0.01	0.03	0.08
7	0.26	0.13	0.15	0.14	-0.01	0.08
8	0.79	0.13	-0.06	-0.19	0.11	0.11
9	-0.21	-0.31	-0.06	-0.04	-0.00	0.00
10	-0.22	-0.69	-0.15	0.17	0.22	0.37
11	-0.34	-0.15	-0.18	-0.10	0.46	0.03
12	-0.03	-0.04	-0.01	-0.06	-0.17	0.00
13	0.04	0.05	0.03	0.08	-0.03	-0.08
14	-0.02	-0.01	-0.10	-0.03	0.03	0.05
15	0.01	-0.12	-0.09	0.00	0.07	-0.01
16	0.10	0.05	-0.05	0.17	-0.02	0.02
17	-0.02	-0.02	-0.09	-0.01	0.02	-0.12
18	0.06	-0.08	-0.10	0.14	0.10	-0.05
19	-0.04	-0.05	-0.18	0.07	-0.01	0.06
20	-0.05	0.01	-0.14	0.05	-0.08	-0.02
21	0.07	0.00	0.14	0.04	0.18	-0.05
22	-0.09	-0.01	-0.01	-0.06	-0.08	-0.02
23	-0.09	0.10	-0.08	-0.06	0.11	-0.05
24	-0.06	0.03	0.05	0.09	0.01	-0.09
25	0.02	-0.02	-0.04	0.01	-0.05	-0.03
26	-0.08	-0.01	-0.03	-0.04	0.13	0.01
27	-0.05	0.10	-0.08	0.07	0.03	-0.00
28	-0.06	-0.00	0.10	-0.02	-0.07	-0.06
29	-0.03	0.02	0.04	-0.06	-0.05	0.10

TABLE B-11

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BACKGROUND ONLY - BACKGROUND ONLY

ELECTRODE POSITION P4

	K		JI		JU	
F	1	2	1	2	1	2
1	-1.40	0.85	-0.40	0.23	0.24	-0.02
2	-0.45	-0.08	0.04	0.04	-0.33	
3	-0.32	-0.44	-0.72	0.07	0.02	-0.12
4	-0.14	0.56	-0.01	-0.10	0.75	0.17
5	-0.13	0.48	-0.09	0.44	-0.17	0.08
6	-0.62	0.34	0.07	0.08	0.03	0.13
7	0.44	0.20	0.32	-0.10	-0.21	-0.09
8	-0.09	0.05	0.36	-0.09	0.12	0.15
9	-0.63	0.19	0.30	-0.42	-0.13	0.14
10	-1.26	0.05	0.78	0.08	0.11	-0.02
11	-0.65	-0.38	-0.06	-0.18	0.15	-0.28
12	0.30	0.10	0.03	-0.30	-0.42	0.02
13	-0.04	0.04	-0.18	-0.27	-0.01	0.16
14	0.21	0.00	-0.11	-0.05	-0.02	-0.12
15	-0.14	0.05	0.12	0.20	0.11	0.27
16	-0.14	0.05	-0.08	0.16	0.02	0.15
17	-0.02	0.16	0.15	0.06	0.12	0.08
18	-0.15	-0.09	0.18	0.13	0.13	0.01
19	0.21	-0.04	0.15	0.21	0.10	0.08
20	-0.05	-0.01	0.01	0.19	-0.07	0.04
21	0.05	-0.01	0.08	-0.00	0.01	0.08
22	0.03	0.02	0.14	0.01	-0.05	0.13
23	0.06	0.12	0.17	-0.01	-0.01	-0.02
24	0.05	-0.09	0.03	0.11	0.19	-0.07
25	-0.07	-0.01	0.03	-0.10	-0.01	0.04
26	0.04	-0.01	-0.19	0.03	0.04	-0.09
27	0.02	0.07	0.07	0.07	0.00	-0.04
28	-0.01	0.01	0.02	0.14	0.13	-0.01
29	-0.05	0.09	0.00	0.07	-0.01	-0.05

TABLE B-12

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS FIGURE FEATURE - FIGURE FEATURE

ELECTRODE POSITION P4

	K		JI		JU	
F	1	2	1	2	1	2
1	-0.88	0.14	-2.05	-1.23	-0.19	-1.28
2	-0.68	-0.09	-0.25	0.11	0.00	-0.48
3	-0.18	-0.21	0.20	-0.42	-0.16	0.04
4	0.40	0.26	0.12	-0.11	0.27	0.09
5	-0.25	0.28	-0.07	0.15	0.49	-0.11
6	0.89	0.36	0.11	0.52	-0.05	-0.27
7	0.39	0.21	0.22	-0.01	-0.10	0.02
8	-0.11	0.19	-0.28	0.06	-0.14	-0.36
9	-0.09	0.68	-0.17	0.62	-0.12	-0.03
10	-0.19	0.51	0.04	0.63	-0.10	0.23
11	-0.14	0.15	-0.20	0.62	0.30	0.14
12	0.38	-0.23	-0.13	0.23	-0.09	0.23
13	-0.20	0.07	-0.10	-0.00	-0.08	0.00
14	-0.06	0.06	-0.02	-0.03	0.14	0.04
15	-0.01	-0.11	0.03	0.03	0.08	-0.12
16	-0.12	0.01	0.03	0.03	-0.18	-0.07
17	-0.22	-0.04	-0.09	-0.15	0.06	0.16
18	0.08	-0.08	-0.07	-0.07	-0.04	-0.06
19	0.06	0.07	-0.08	0.05	-0.07	0.17
20	-0.13	-0.09	-0.16	0.12	0.07	-0.05
21	0.04	0.07	-0.06	-0.12	-0.02	0.09
22	-0.07	0.01	-0.30	-0.02	-0.01	-0.02
23	0.06	0.03	0.07	0.10	0.24	-0.01
24	0.01	0.02	-0.13	-0.08	-0.04	0.03
25	0.01	0.09	0.16	0.18	0.09	0.06
26	0.04	0.01	0.03	0.06	0.04	0.07
27	-0.04	-0.05	0.03	0.09	-0.01	-0.07
28	-0.02	0.08	0.07	0.01	0.01	-0.04
29	-0.06	0.02	-0.07	-0.00	0.04	-0.10

TABLE B-13

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BLANK - BLANK

ELECTRODE POSITION 01

	K		JI		JU	
F	1	2	1	2	1	2
1	-0.52	0.70	-0.02	-0.65	0.22	-0.19
2	-0.12	0.01	0.49	-0.18	-0.20	0.28
3	0.01	0.38	0.05	0.03	-0.11	-0.25
4	-0.05	-0.37	0.11	-0.17	-0.05	0.06
5	0.24	0.16	0.09	-0.22	0.06	-0.08
6	0.15	-0.17	0.06	0.00	0.11	0.08
7	-0.16	0.01	-0.30	-0.12	0.11	0.11
8	0.12	0.10	-0.17	-0.10	0.06	0.04
9	-0.09	-0.01	-0.16	0.08	-0.11	0.20
10	0.31	-0.28	-0.11	0.37	-0.05	0.23
11	-0.21	-0.06	-0.01	-0.02	0.18	0.30
12	-0.05	-0.05	-0.03	-0.16	0.01	-0.14
13	-0.26	-0.17	-0.01	0.09	-0.03	0.04
14	-0.24	-0.18	0.21	-0.12	0.08	-0.17
15	-0.25	-0.01	0.10	0.22	-0.04	-0.08
16	-0.30	-0.07	0.09	0.00	0.11	0107
17	0.10	-0.03	0.11	-0.13	0.07	-0.03
18	-0.06	-0.05	-0.10	0.11	0.02	0.02
19	0.03	-0.04	-0.07	0.02	0.12	0.13
20	0.07	0.08	0.00	0.06	0.06	0.09
21	0.00	0.04	0.12	0.06	0.08	0.05
22	-0.13	0.05	0.07	0.13	-0.03	0.02
23	-0.09	0.00	0.07	0105	0.13	0.03
24	-0.12	-0.07	0.03	0.15	-0.02	0.02
25	-0.04	-0.01	0.06	0.06	-0.02	-0.01
26	-0.06	0.00	0.02	0.01	0.05	0.01
27	0.08	0.15	0.04	0.24	0.01	0.03
28	-0.15	0.12	-0.04	-0.03	-0.06	-0.02
29	0.02	0.00	0.09	-0.02	-0.03	0104

TABLE B-14

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BACKGROUND ONLY - BACKGROUND ONLY

ELECTRODE POSITION 01

	K		JI		JU	
F	1	2	1	2	1	2
1	-0.92	-0.84	-0.36	-0.14	-0.99	-0.60
2	0.45	-0.24	-0.22	-0.60	-0.25	0.01
3	0.13	0.58	0.23	0.47	-0.14	0.03
4	0.28	0.01	-0.01	-0.68	-0.02	0.07
5	-0.07	0.00	0.28	0.44	-0.11	-0.04
6	-0.03	-0.10	-0.04	0.05	-0.12	-0.03
7	0.03	-0.11	-0.04	0.09	-0.12	-0.10
8	-0.05	-0.15	0.09	0.24	-0.04	-0.25
9	-0.12	-0.03	0.37	0.02	-0.10	0.23
10	-0.61	-0.16	0.22	0.08	-0.23	0.12
11	-0.45	-0.36	0.34	-0.20	-0.00	0.02
12	0.14	0.18	0.16	0.18	-0.19	0.07
13	-0.08	0.30	0.03	-0.08	0.12	-0.06
14	-0.43	-0.16	-0.00	-0.08	0.03	-0.14
15	0.17	0.03	0.18	-0.02	0.01	0.24
16	-0.10	-0.07	-0.18	-0.06	-0.04	0.10
17	0.05	0.02	-0.04	-0.07	-0.03	-0.02
18	-0.11	-0.04	0.10	0.05	0.01	0.01
19	0.16	0.01	0.14	0.12	0.08	0104
20	0.20	0.07	0.08	-0.09	0104	0.08
21	-0.04	0102	0.02	-0.17	0.06	0.10
22	-0.01	-0.02	0.03	-0.08	-0.01	-0.05
23	-0.11	0.02	-0.02	0.06	0.02	0.05
24	0.01	-0.15	0.09	0.20	0.16	0.09
25	0109	0109	-0.15	0103	0.10	0.09
26	-0.05	0.01	0.16	0.12	0.07	0.09
27	-0.10	0.03	-0.00	0.02	-0.01	0.20
28	-0.05	-0.01	-0.16	-0.09	0.04	-0.01
29	-0.03	0.15	-0.02	0.05	0.01	0.01

TABLE B-15

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS FIGURE FEATURE - FIGURE FEATURE

ELECTRODE POSITION 01

	K		JI		JU	
F	1	2	1	2	1	2
1	-0.16	-0.34	-2.47	-2.24	-0.60	-0.27
2	0.22	0.51	-0.06	0.20	-0.21	0.02
3	-0.26	-1.02	0.13	0.36	-0.01	-0.03
4	0.01	-0.08	-0.04	0.09	0.61	0.27
5	-0.25	-0.09	0.35	-0.53	0.87	-0.13
6	-0.06	0.18	0.41	0.16	0.28	-0.31
7	-0.27	0.18	-0.04	0.28	0.19	-0.09
8	-0.24	0.13	0.14	0.17	-0.14	-0.16
9	-0.07	-0.16	-0.05	0.16	-0.11	-0.21
10	0.15	0.22	0.08	0.38	-0.04	0.03
11	0.11	0.11	-0.12	0.70	0.19	-0.08
12	0.19	0.04	0.16	0.03	-0.18	-0.05
13	-0.29	0.03	-0.23	-0.07	0.03	-0.21
14	0.00	-0.22	-0.12	-0.03	0.05	-0.11
15	-0.21	0.04	-0.10	0.04	-0.24	-0.03
16	-0.16	-0.19	0.03	-0.01	-0.05	-0.11
17	-0.28	0.09	-0.02	-0.01	0.00	-0.03
18	0.03	-0.03	0.05	0.15	0.08	0.03
19	-0.00	-0.12	-0.04	0.21	0.03	0.12
20	0.04	-0.02	0.13	0.08	0.09	0.03
21	-0.13	0.03	-0.08	-0.10	0.03	0.07
22	-0.02	-0.03	0.11	0.04	-0.02	-0.04
23	0.15	0.01	0.09	0.05	0.03	0.05
24	0.03	0.06	-0.11	0.08	0.16	0.06
25	-0.00	-0.04	-0.02	0.04	-0.01	0.10
26	-0.03	-0.02	0.05	0.20	0.00	0.01
27	0.09	-0.06	0.03	0.07	0.08	-0.00
28	-0.05	0.11	-0.00	0.03	-0.06	-0.02
29	-0.09	0.04	-0.01	0.08	0.05	-0.08

TABLE B-16

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BLANK - BLANK

ELECTRODE POSITION 02

	K		JI		JU	
F	1	2	1	2	1	2
1	-0.05	0.90	0.06	-0.63	0.27	-0.52
2	-0.18	0.10	0.23	0.00	-0.09	0.14
3	0.21	0.31	-0.09	-0.04	0.18	0.00
4	0.08	-0.23	0.05	-0.10	-0.10	0.01
5	0.04	0.00	0.14	-0.13	0.12	-0.07
6	-0.14	-0.25	0.04	-0.04	-0.01	0.07
7	0.05	-0.18	-0.13	-0.04	-0.09	0.08
8	0.31	0.01	-0.07	-0.05	0.13	0.08
9	-0.17	-0.21	-0.09	-0.03	-0.06	0.29
10	-0.13	-0.44	-0.07	0.30	0.07	0.02
11	-0.16	0.00	-0.06	0.03	0.51	0.00
12	0.06	0.07	-0.05	-0.13	0.00	-0.15
13	-0.09	0.02	0.08	0.08	-0.01	0.03
14	-0.12	-0.11	0.07	-0.08	-0.01	-0.09
15	-0.24	-0.03	0.05	0.13	-0.00	0.05
16	-0.10	-0.03	-0.02	0.08	0.02	0.06
17	-0.03	-0.10	-0.05	-0.01	0.08	0.01
18	0.04	0.04	0.00	0.01	-0.09	-0.01
19	0.01	-0.02	-0.08	-0.02	0.00	0.13
20	-0.02	0.04	-0.11	0.11	0.02	-0.05
21	0.06	-0.04	0.18	-0.02	0.18	0.02
22	0.00	0.01	0.02	0.08	0.02	0.02
23	-0.05	-0.01	0.05	-0.04	0.10	0.01
24	-0.13	-0.10	0.01	0.13	-0.06	-0.09
25	0.07	-0.04	0.02	0.00	-0.02	0.04
26	-0.11	-0.06	0.11	0.05	0.07	0.00
27	0.03	0.15	0.00	0.20	-0.03	0.04
28	-0.09	0.02	-0.02	0.01	-0.05	-0.08
29	0.01	0.10	0.08	-0.01	-0.00	0.13

TABLE B-17

ERROR-CONTROL DATA

AMPLITUDE DIFFERENCES (μV)

STIMULUS BACKGROUND ONLY - BACKGROUND ONLY

ELECTRODE POSITION 02

	K		JI		JU	
F	1	2	1	2	1	2
1	-1.16	-0.99	-0.61	0.40	-0.69	-0.40
2	0.35	-0.38	-0.31	0.60	0.11	-0.00
3	-0.45	0.15	0.01	0.57	0.17	-0.07
4	0.29	0.26	-0.11	-0.58	0.26	0.07
5	-0.03	-0.08	0.19	0.30	-0.03	-0.10
6	0.02	0.11	0.04	-0.01	0.03	-0.10
7	-0.08	-0.12	0.17	0.11	-0.06	-0.07
8	0.02	0.06	0.20	0.15	0.21	-0.22
9	-0.42	0.07	0.28	-0.12	-0.11	0.17
10	-1.25	0.25	0.09	0.15	0.03	-0.03
11	-1.08	-0.55	0.23	-0.15	0.00	-0.06
12	0.28	0.11	0.12	0.08	-0.30	-0.04
13	0.21	0.21	-0.04	-0.05	0.06	-0.22
14	-0.15	-0.02	0.09	-0.09	-0.00	-0.20
15	0.00	0.04	0.16	0.12	0.13	0.29
16	-0.12	0.03	-0.15	0.05	0.21	0.08
17	-0.02	0.00	0.01	-0.13	0.12	-0.08
18	-0.18	0.02	0.17	-0.03	0.01	0.02
19	0.25	-0.05	0.16	0.23	-0.06	0.01
20	0.00	0.11	0.10	0.08	-0.04	0.14
21	0.02	0.04	0.09	-0.09	0.02	0.06
22	0.02	-0.01	0.04	-0.06	-0.04	0.05
23	-0.01	-0.02	0.06	0.06	-0.01	0.03
24	0.01	-0.07	0.08	0.16	0.22	0.04
25	-0.01	0105	-0.04	-0.05	0.05	0.08
26	0.07	-0.03	-0.09	0.05	0.00	0.06
27	-0.00	-0.02	-0.02	0.00	-0.03	0.11
28	0.07	0.06	-0.05	-0.02	0.09	0.01
29	-0.05	0.05	-0.07	0.07	0.04	0103

TABLE B-18

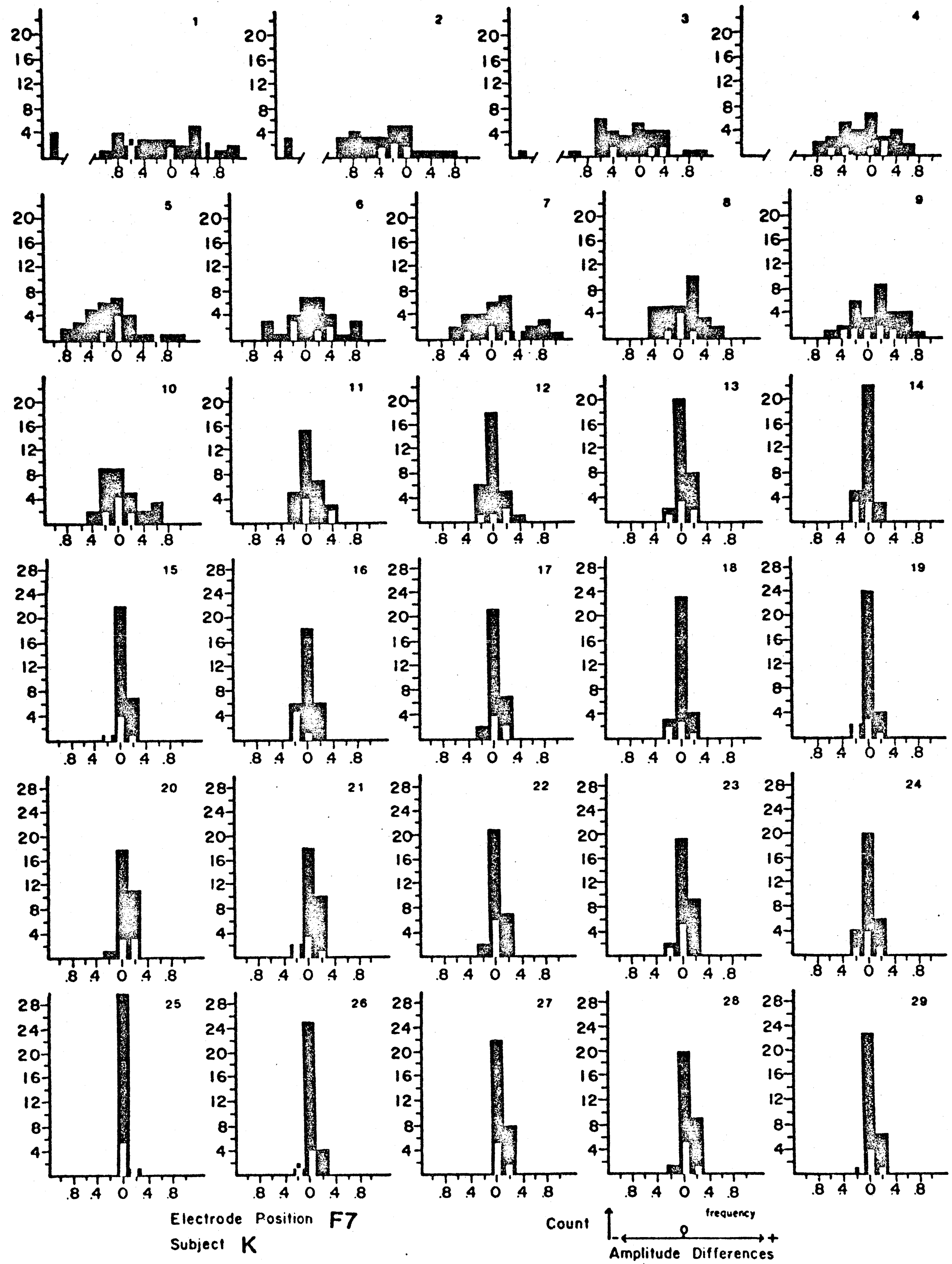
ERROR-CONTROL DATA

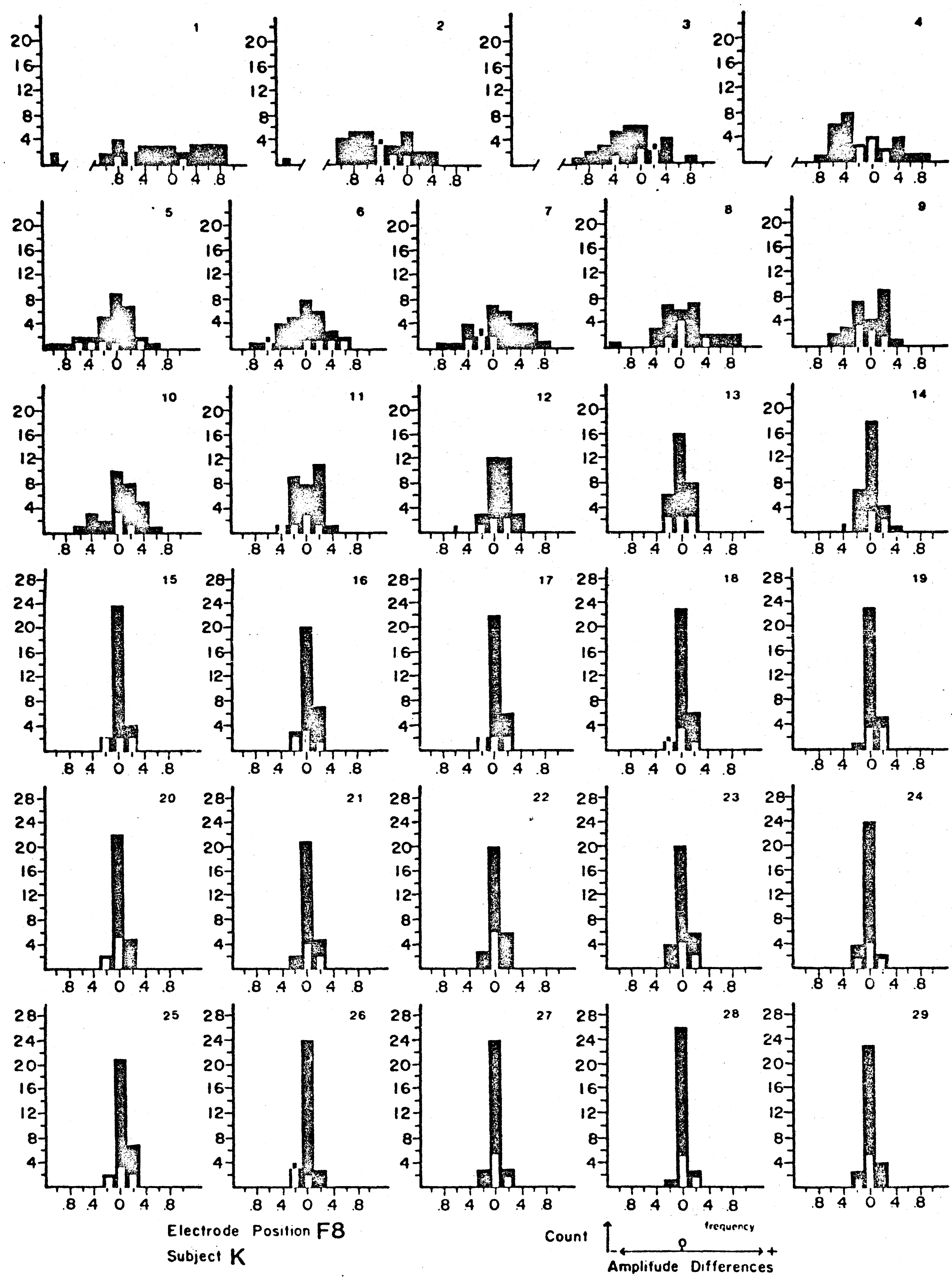
AMPLITUDE DIFFERENCES (μV)

STIMULUS FIGURE FEATURE - FIGURE FEATURE

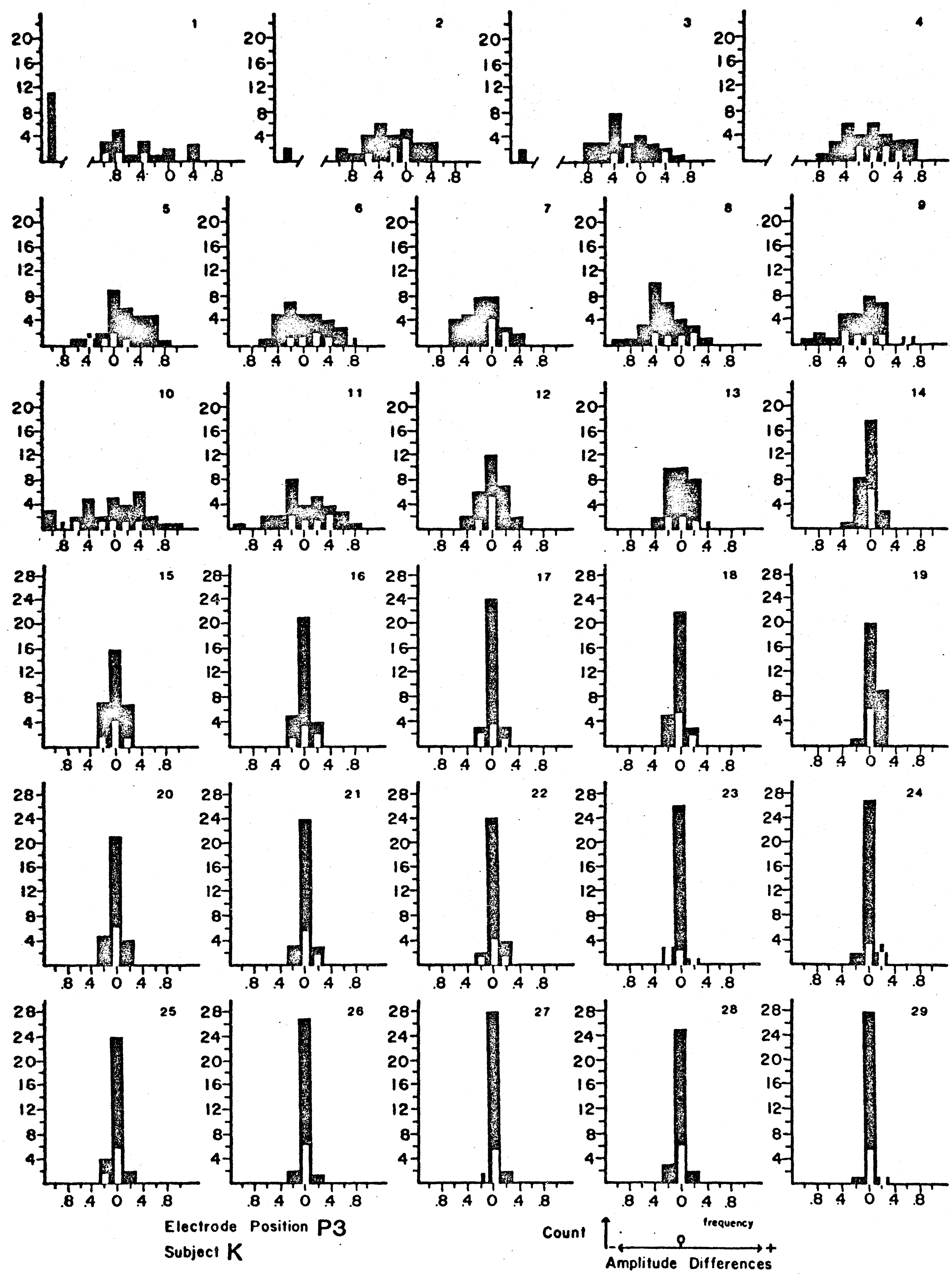
ELECTRODE POSITION 02

F	K 1	K 2	JI 1	JI 2	JU 1	JU 2
1	-0.58	-0.54	-1.73	-1.57	-0.42	-0.73
2	-0.21	0.07	0.00	0.37	0.11	-0.38
3	-0.21	-1.02	0.01	0.36	0.20	-0.06
4	0.45	-0.13	0.15	0.04	0.63	0.16
5	-0.15	-0.15	0.14	0.00	0.91	-0.24
6	0.49	-0.07	0.44	0.30	0.43	-0.38
7	0.41	-0.02	-0.18	-0.19	0.04	-0.05
8	0.04	-0.00	0.04	-0.12	-0.05	-0.13
9	-0.25	-0.18	-0.06	0.31	-0.15	-0.16
10	-0.10	0.43	0.01	0.32	0.10	0.04
11	-0.13	0.02	-0.13	0.36	0.29	0.10
12	0.24	-0.18	-0.00	0.06	-0.19	-0.12
13	-0.02	0.14	-0.30	-0.09	-0.02	-0.24
14	-0.11	-0.15	-0.08	-0.13	0.05	0.02
15	-0.08	-0.20	-0.11	0.00	-0.07	-0.00
16	0.00	-0.16	-0.02	0.15	0.15	-0.15
17	-0.31	-0.06	-0.11	0.10	0.09	-0.02
18	-0.02	-0.04	-0.11	0.16	0.03	-0.08
19	-0.05	0.03	-0.08	0.21	0.02	0.15
20	0.01	-0.14	0.09	0.11	0.00	0.01
21	-0.04	-0.06	0.01	-0.08	0.02	0.01
22	-0.07	-0.03	-0.03	-0.01	-0.01	-0.07
23	0.15	-0.01	0.07	0.09	0.05	0.04
24	0.11	-0.01	0.02	0.08	0.13	0.02
25	0.04	0.03	0.04	-0.03	-0.06	0.11
26	0.11	0.14	0.01	0.16	-0.09	-0.02
27	-0.01	-0.12	0.03	0.02	0.11	-0.07
28	0.02	-0.00	0.07	0.09	-0.01	0.05
29	-0.04	0.05	0.08	0.02	0.05	-0.05

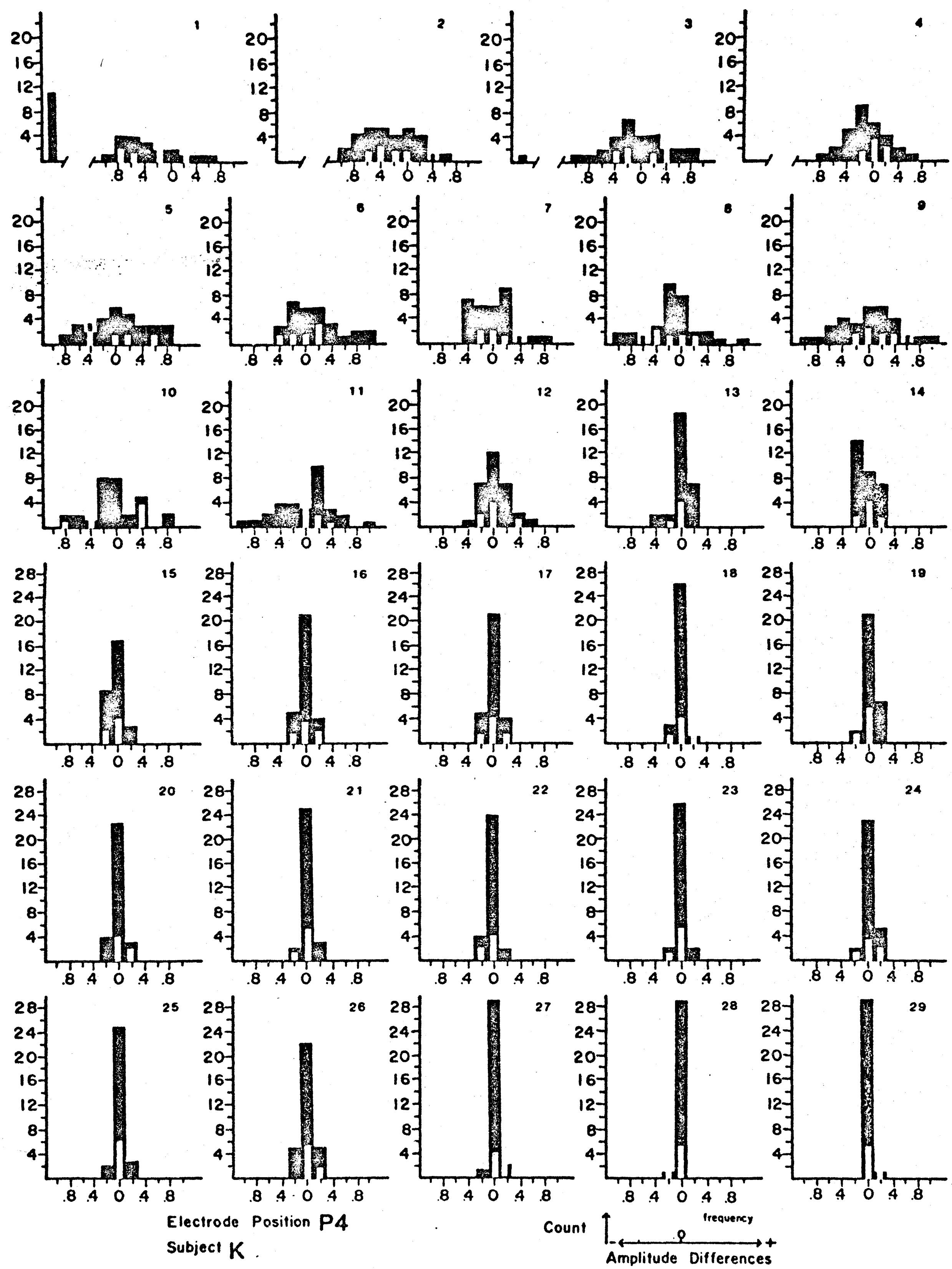

Electrode Position F7
Subject K
Count
frequency
Amplitude Differences

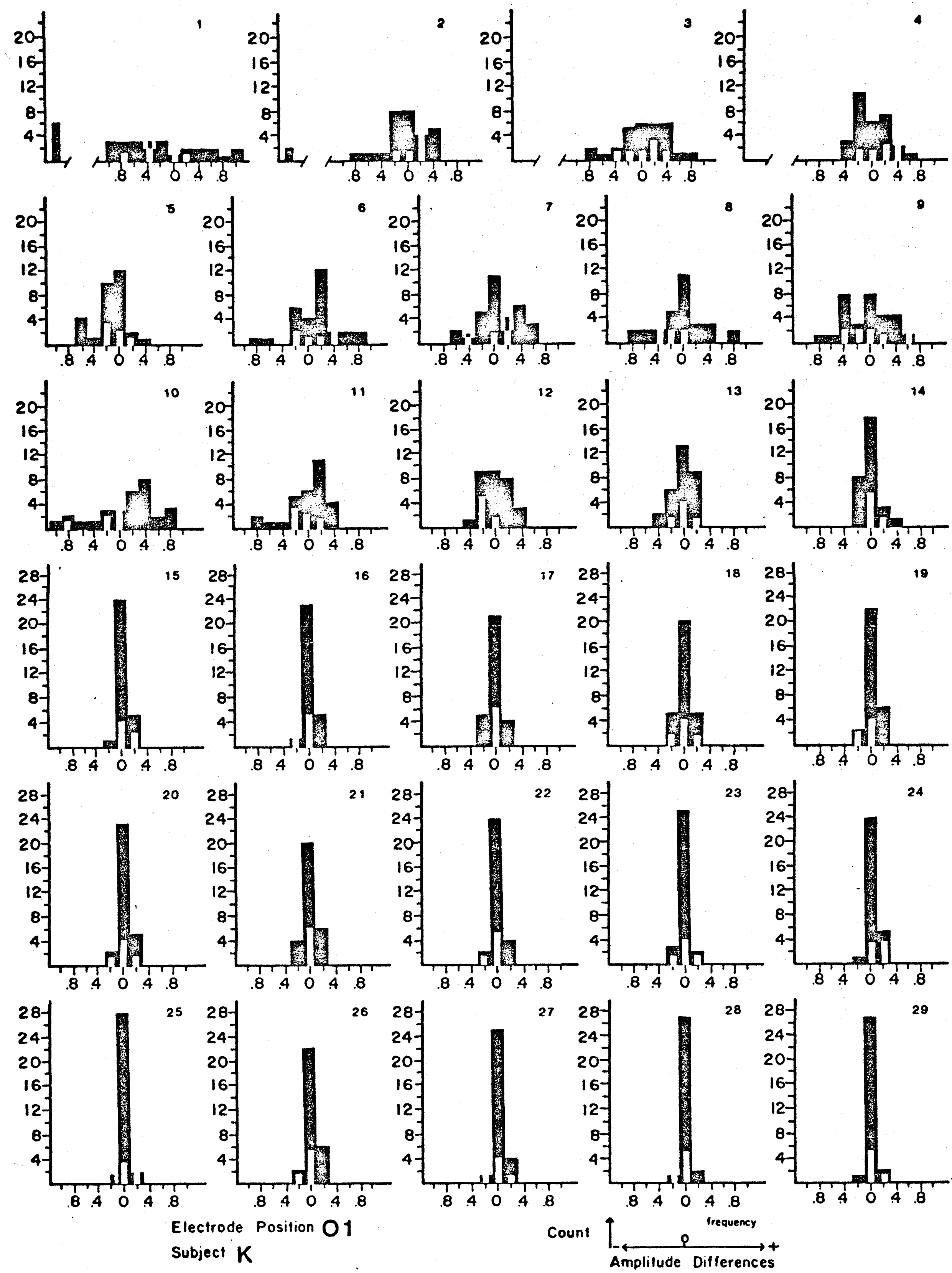


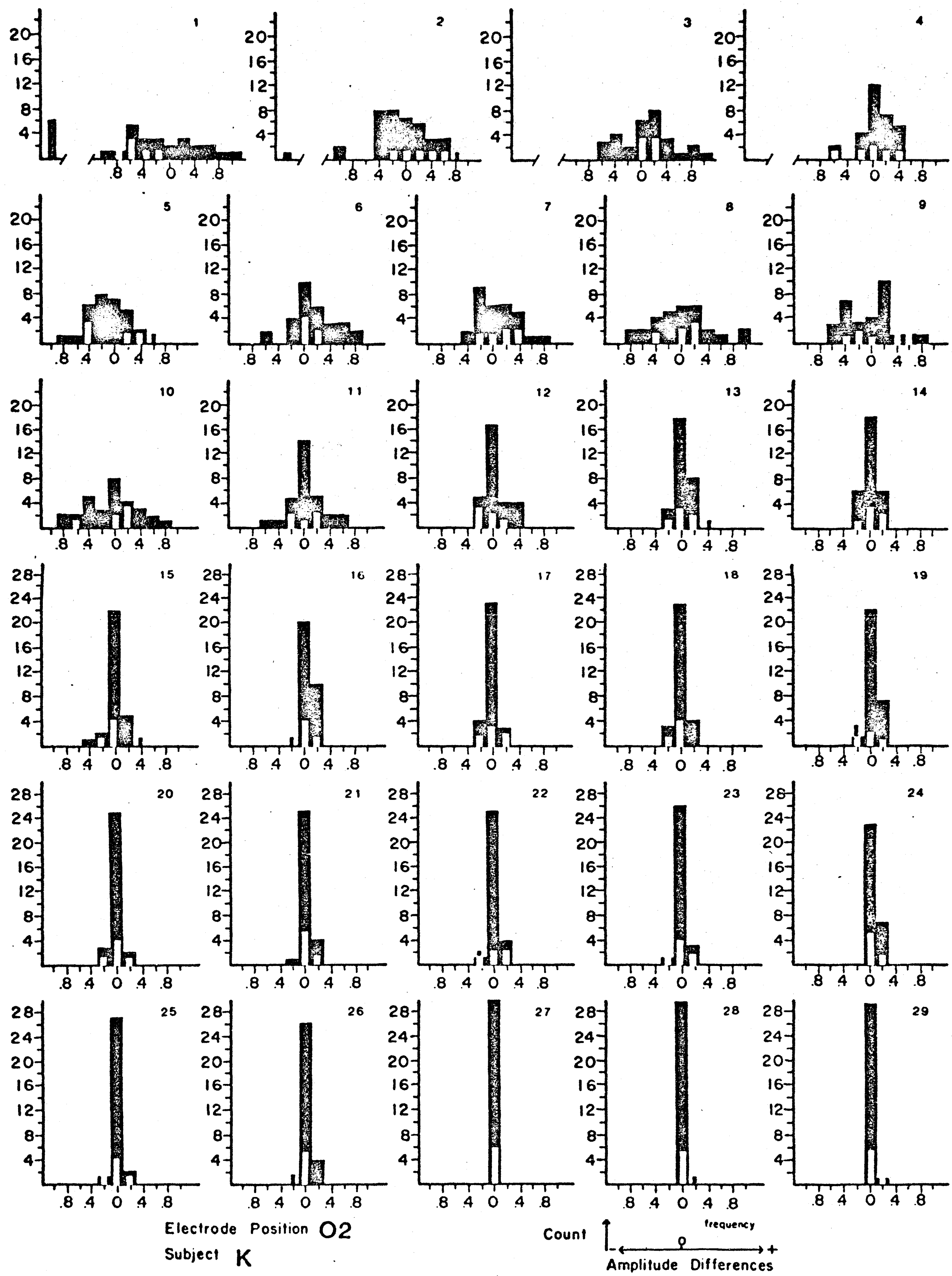
Electrode Position F8
Subject K



Electrode Position P3
Subject K
Count
frequency
Amplitude Differences


Electrode Position P4
Subject K
Count
frequency
Amplitude Differences


Electrode Position O1
Subject K
Count
frequency
Amplitude Differences



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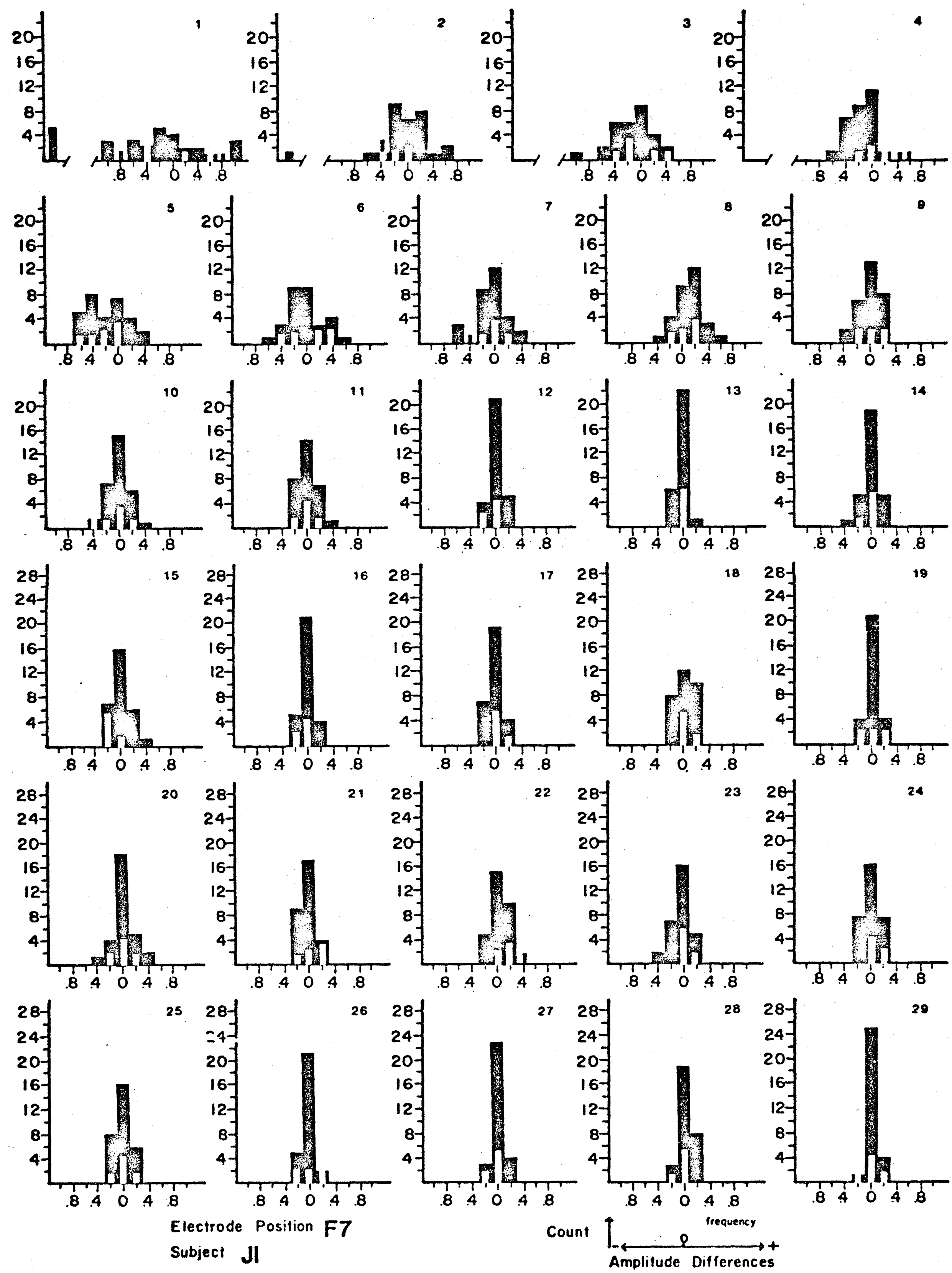
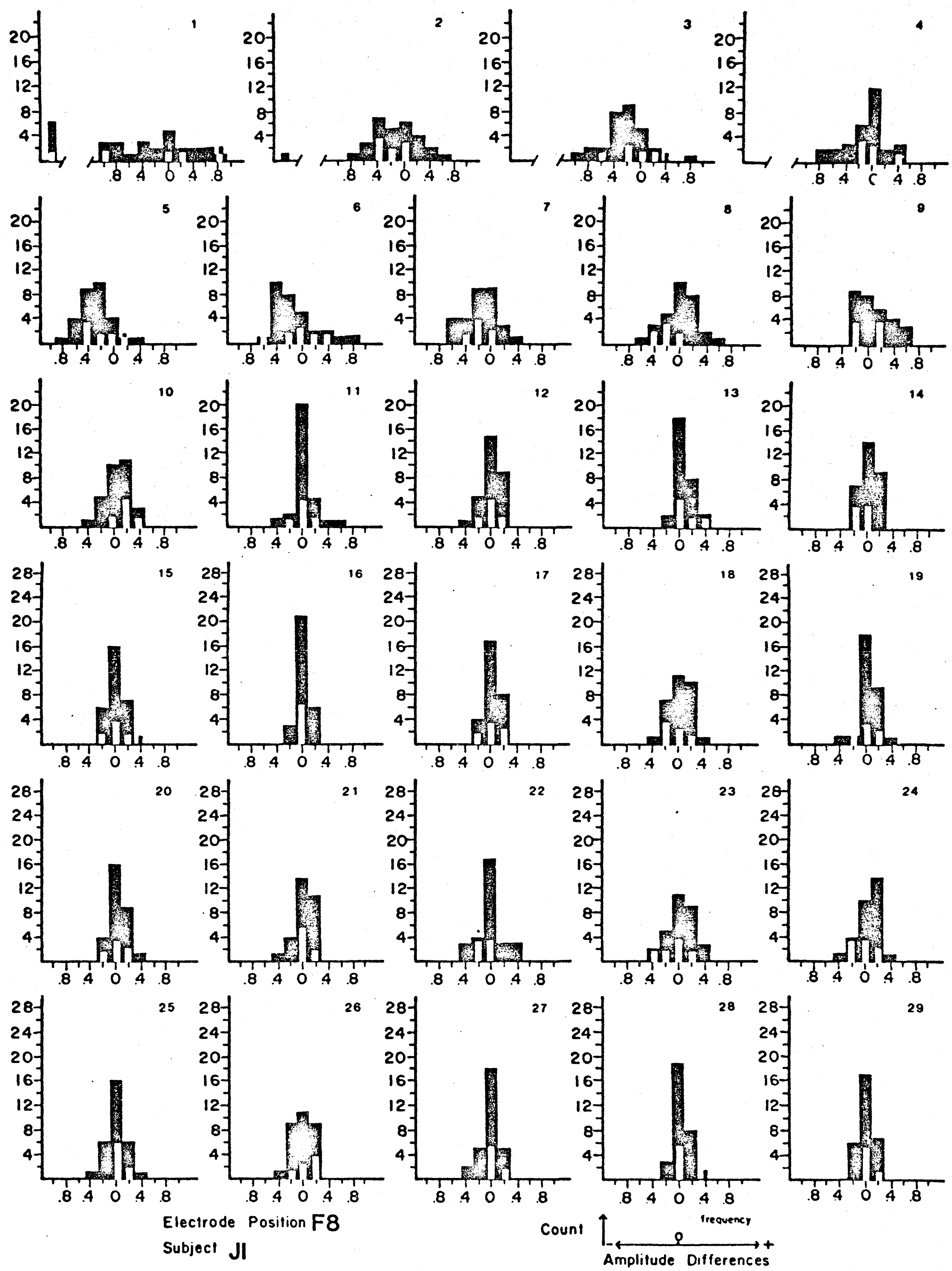
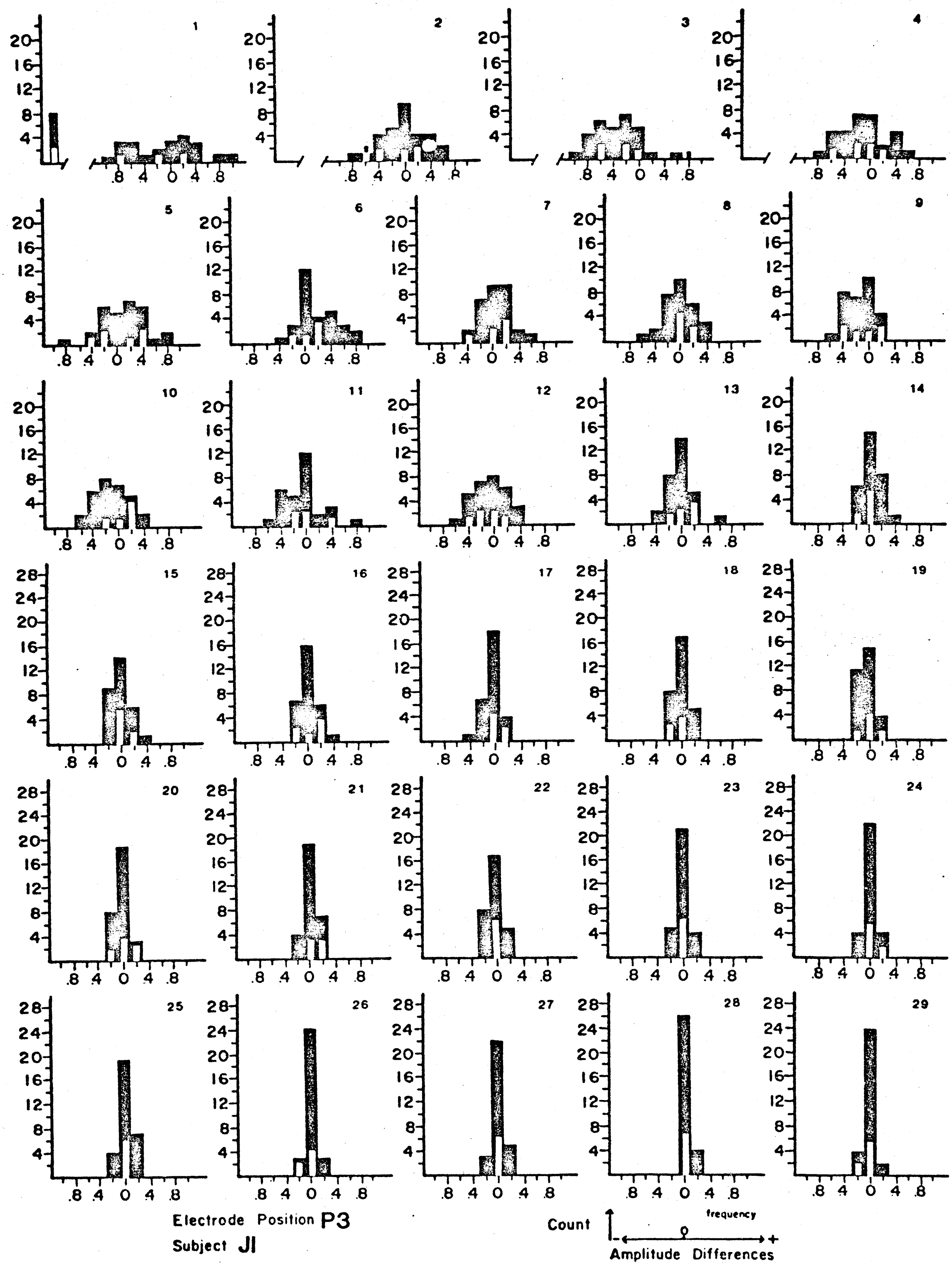
Electrode Position O2
Subject K
Count
frequency
Amplitude Differences

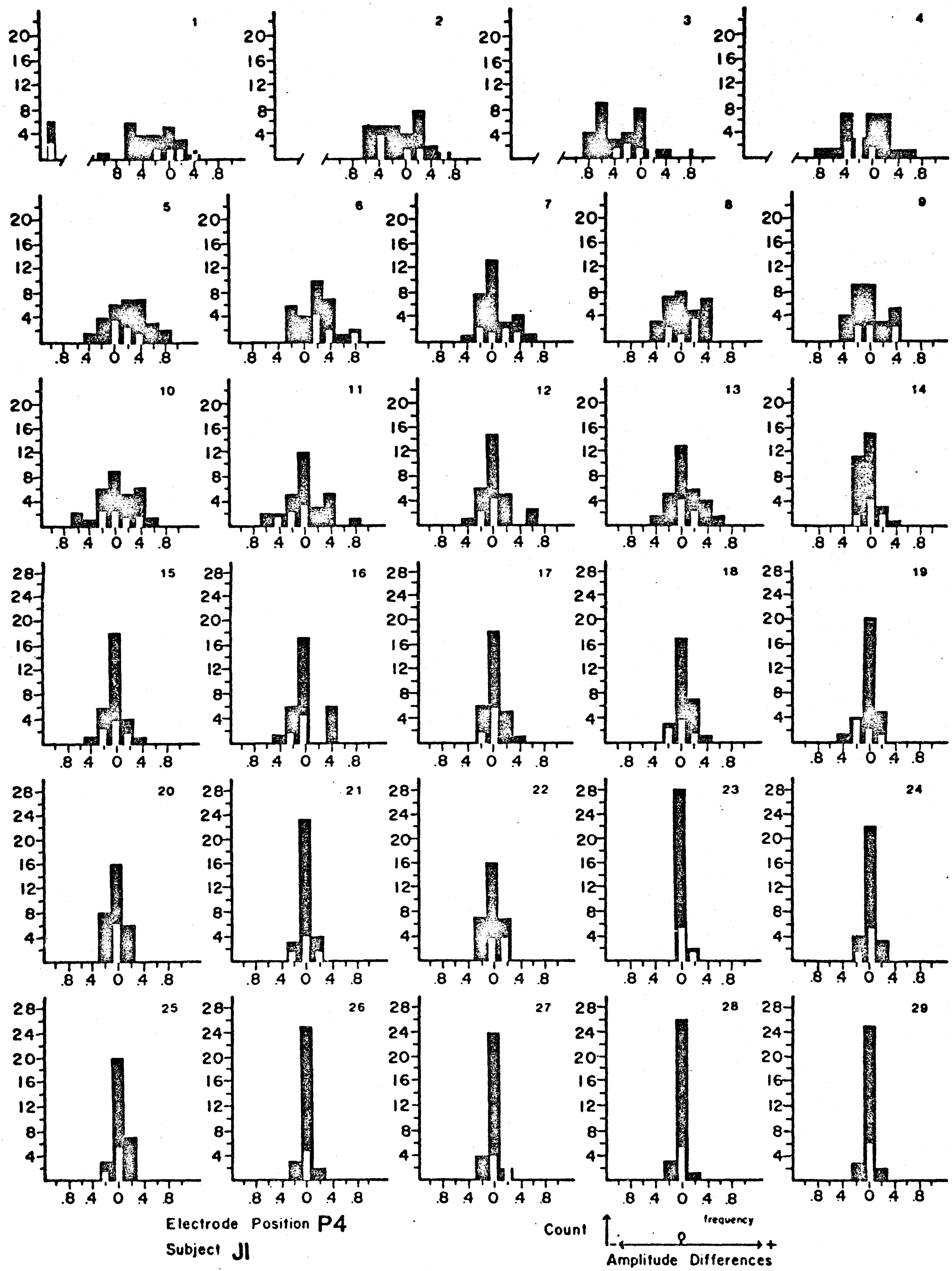

Electrode Position F7
Subject JI
Count
frequency
Amplitude Differences

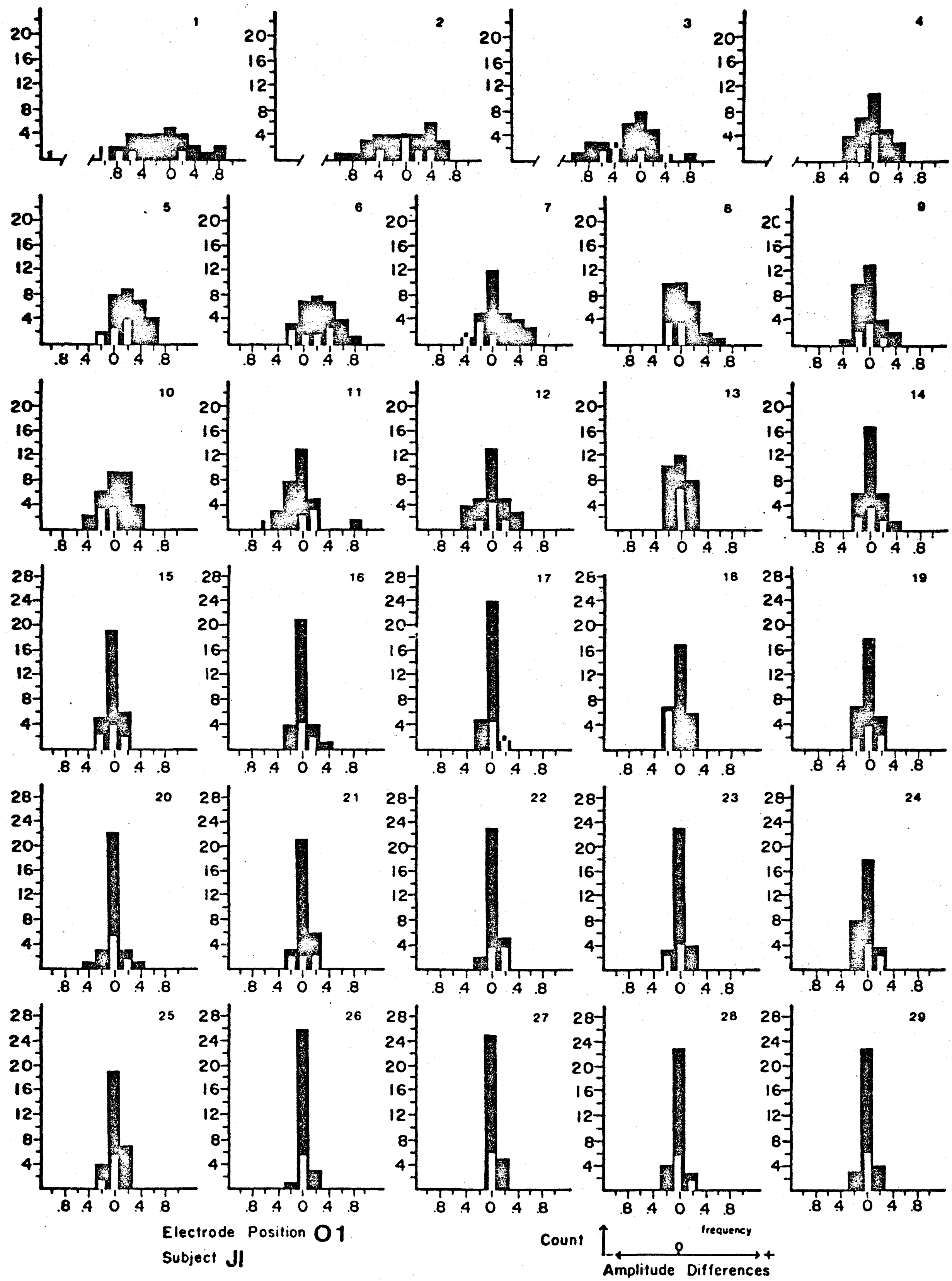


Electrode Position F8

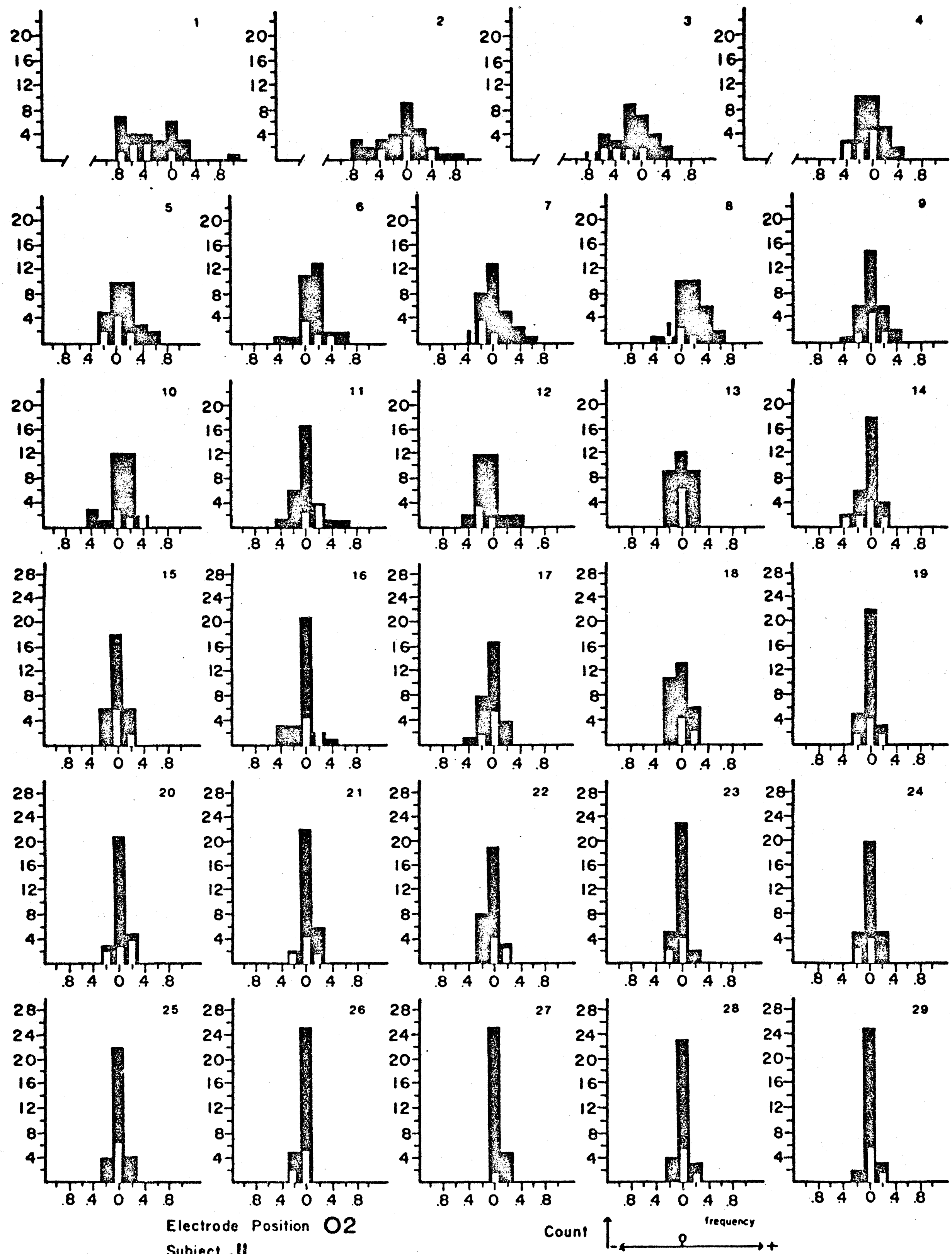
Subject JI

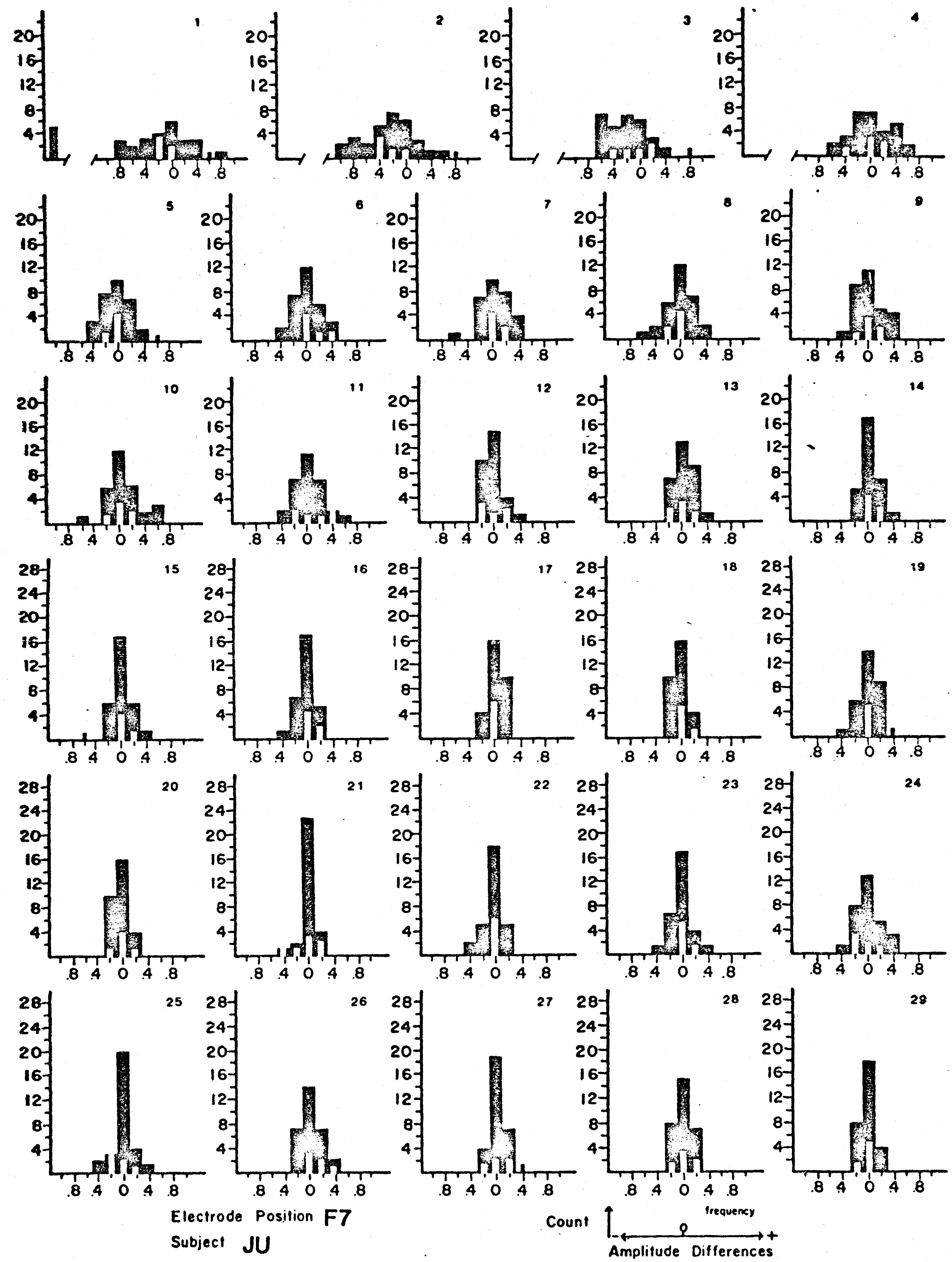

Electrode Position P3
Subject JI
Count
frequency
Amplitude Differences

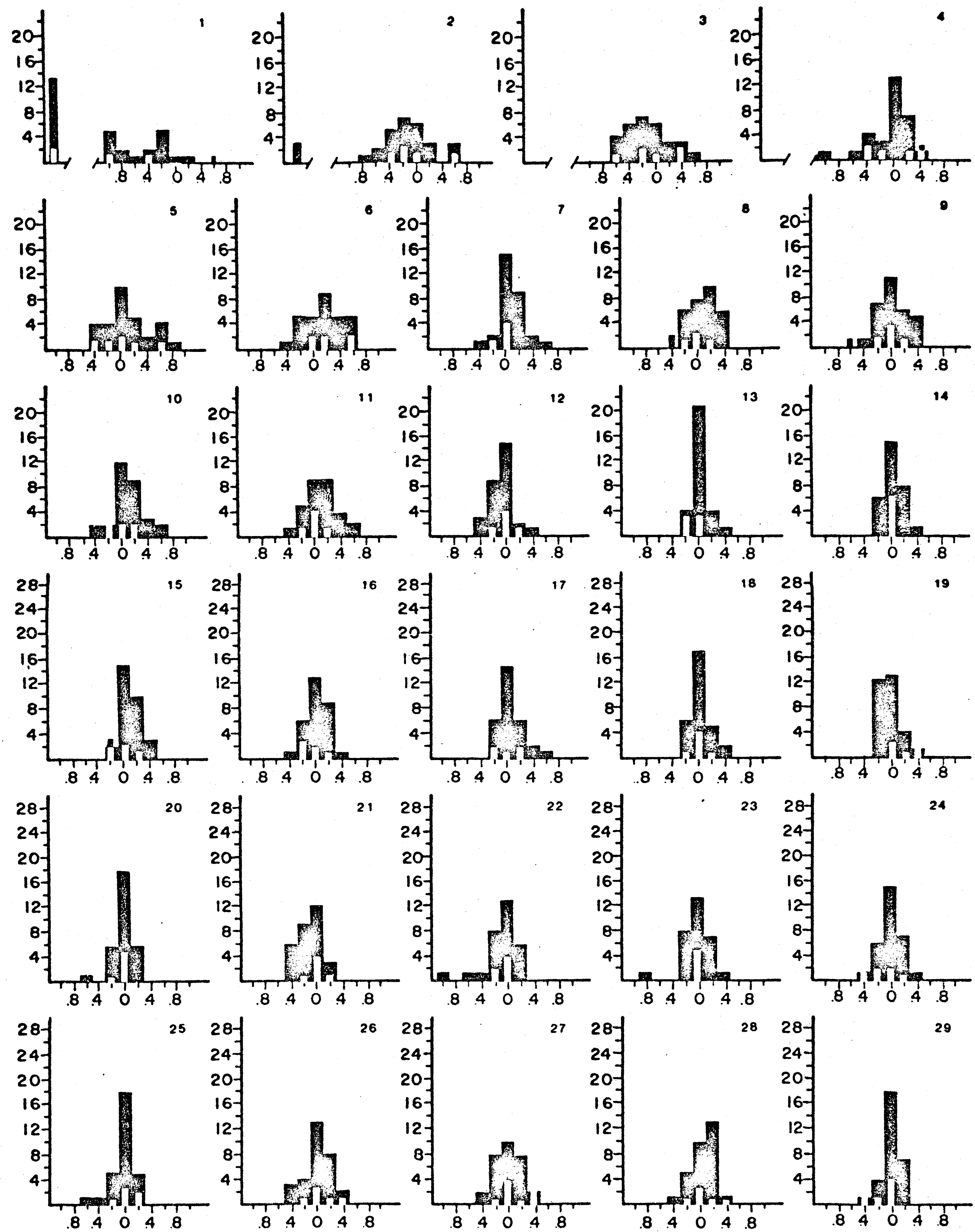

Electrode Position P4
Subject JI
Count
frequency
Amplitude Differences



Electrode Position O1
Subject JI
Count
frequency
Amplitude Differences

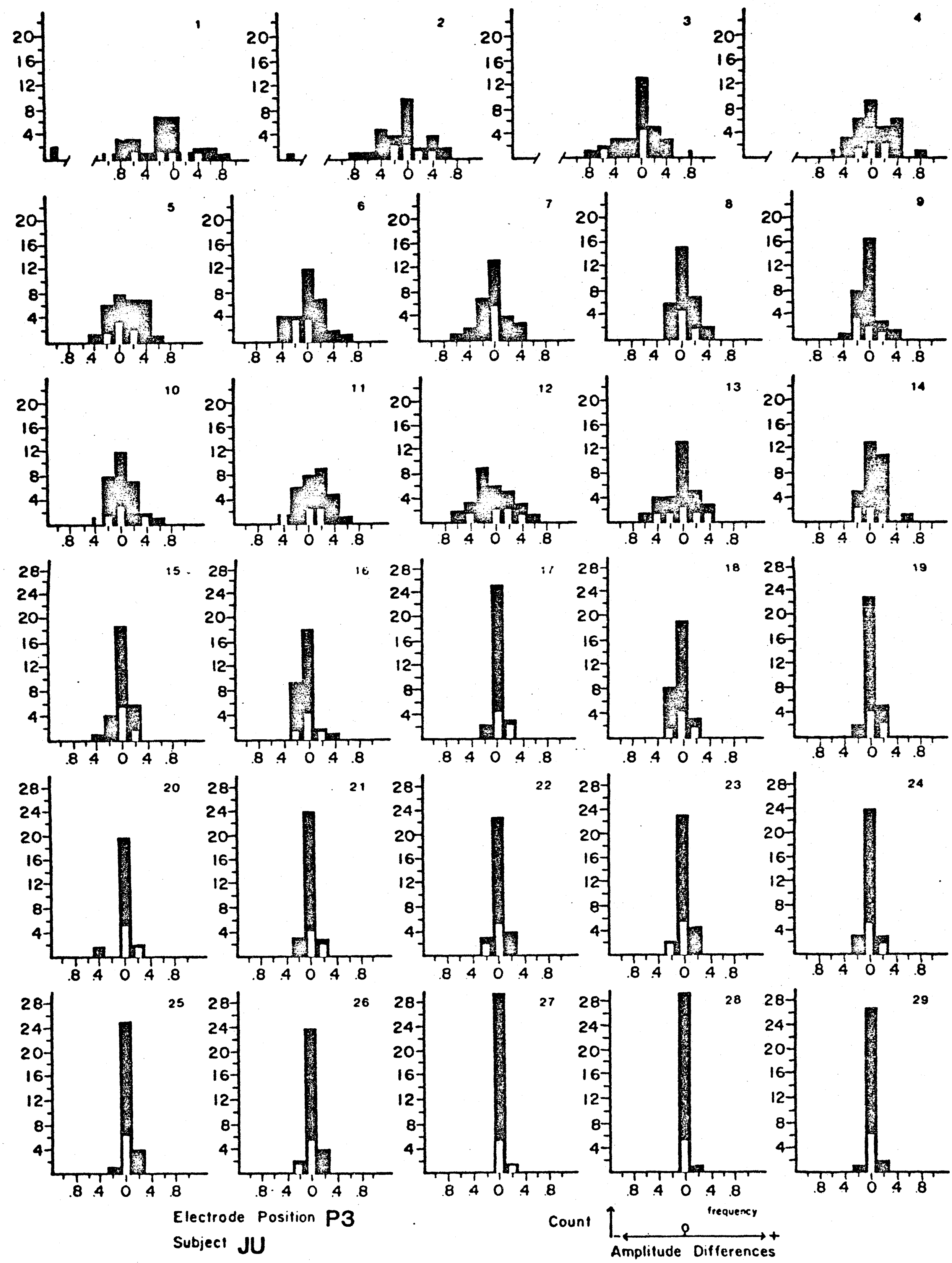

Electrode Position O2
Subject JI
Count
frequency
Amplitude Differences


Electrode Position F7
Subject JU
Count
frequency
Amplitude Differences

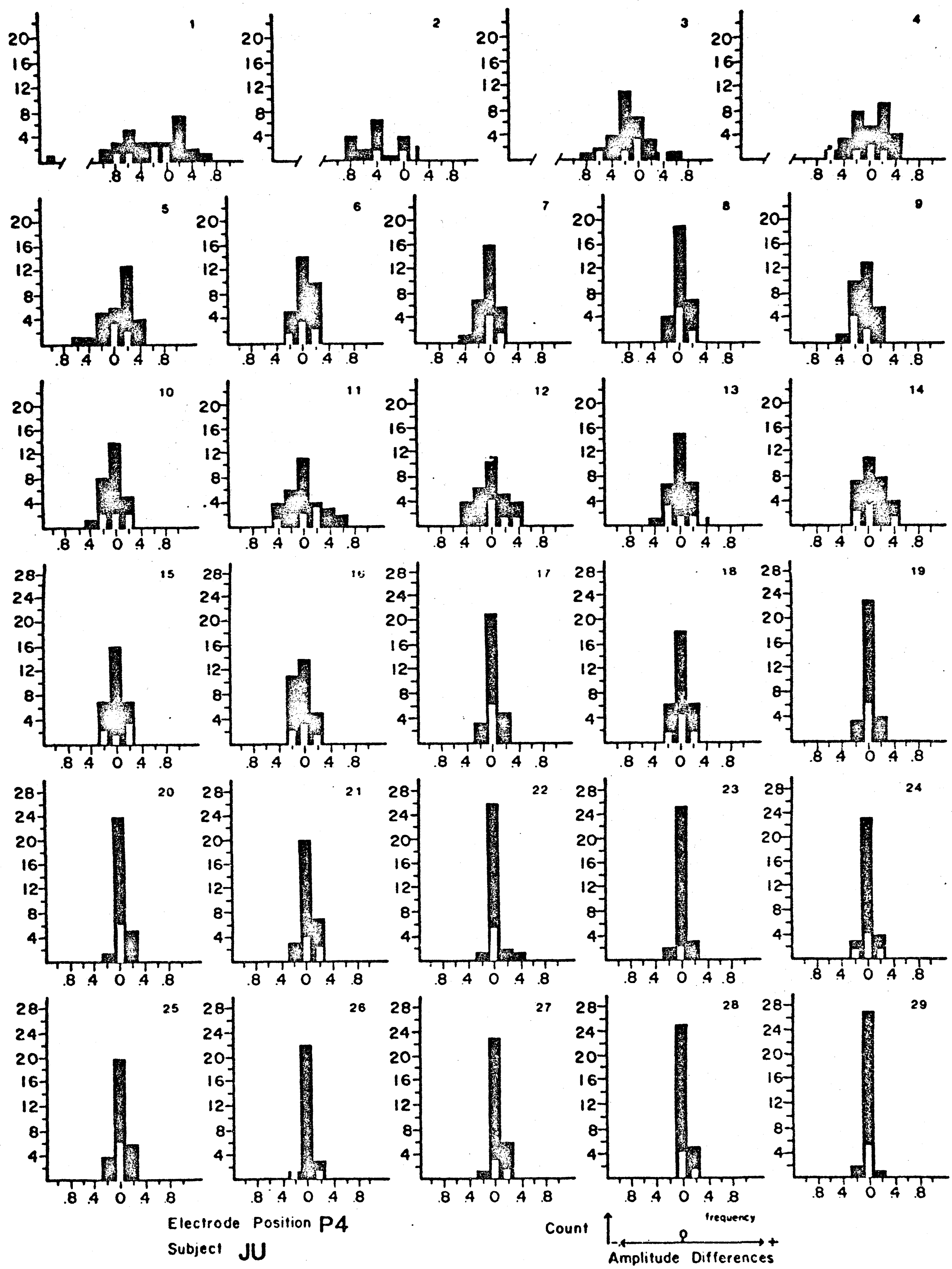


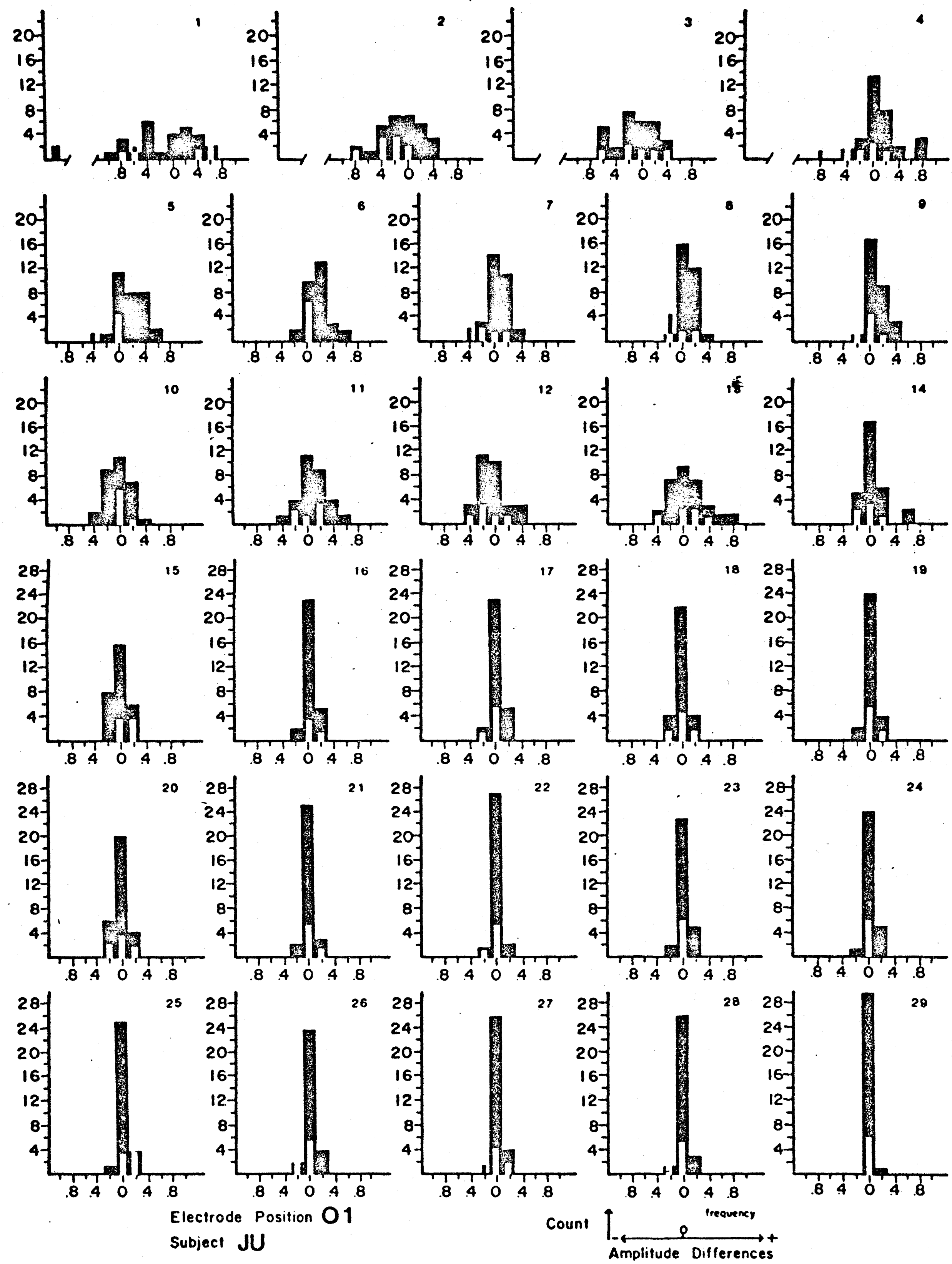
Electrode Position F8
Subject JU

Count frequency
Amplitude Differences

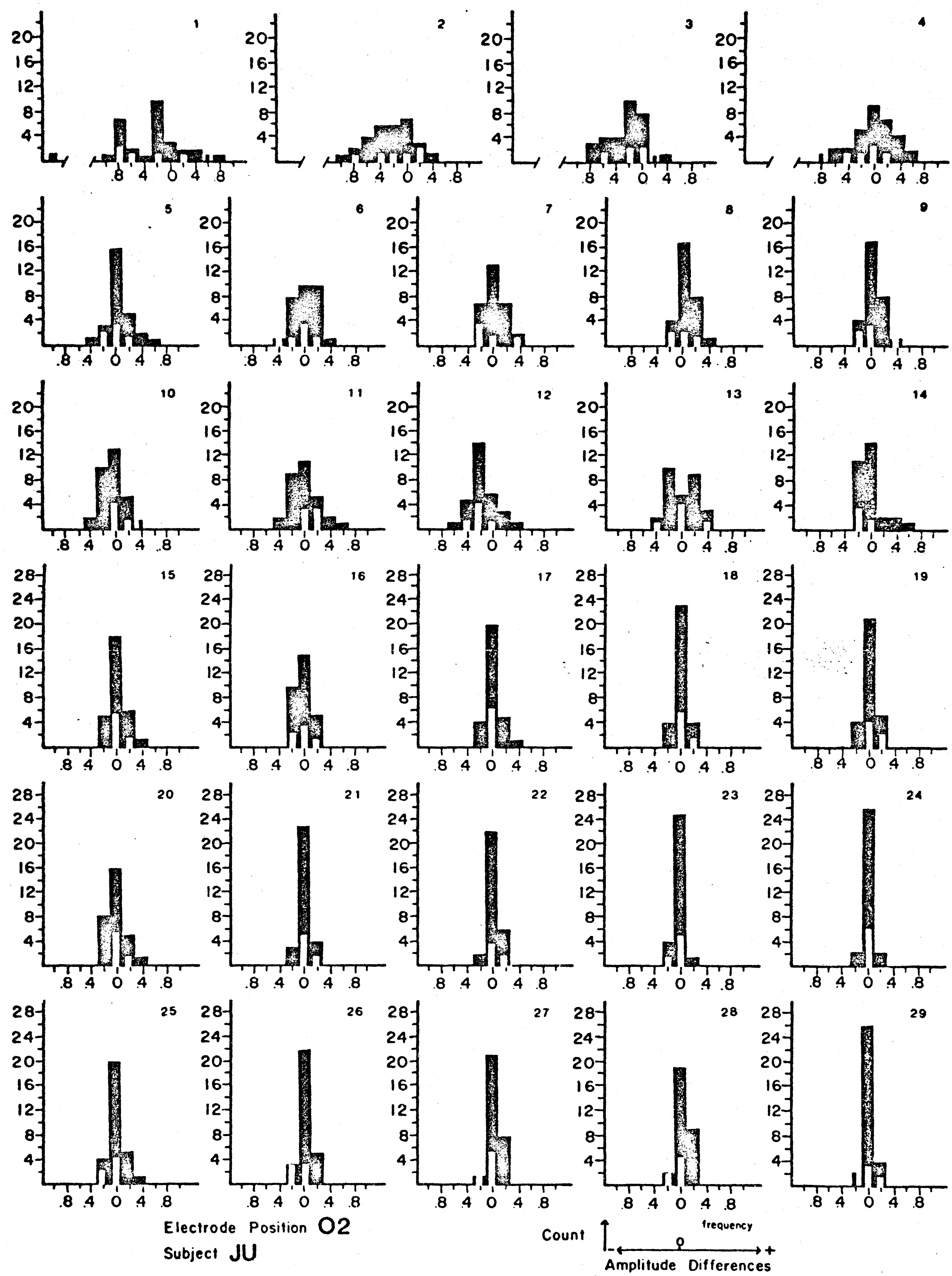


Electrode Position P3
Subject JU
Count
frequency
Amplitude Differences


Electrode Position P4
Subject JU
Count
frequency
Amplitude Differences



Electrode Position O1
Subject JU
Count
frequency
Amplitude Differences


Electrode Position O2
Subject JU
Count
frequency
Amplitude Differences

APPENDIX C

Control Data Comparisons

Tables C-1 through C-9 give the Fourier frequency components (f, in Hz) at which $\overline{\Sigma 64}$ VERs obtained from unlike control stimuli were different. Difference was determined when the absolute value of the difference between corresponding frequency component amplitudes in two different $\overline{\Sigma 64}$ VERs was greater than the absolute value of the difference between the same corresponding frequency amplitudes in both the first $\overline{\Sigma 32}$ VER and its replication, making up the $\overline{\Sigma 64}$ VER from the first stimulus, and the second $\overline{\Sigma 32}$ VER and its replication, making up the $\overline{\Sigma 64}$ VER from the second stimulus.

Columns labeled "1" refer to $\overline{\Sigma 64}$ VERs that are the mean of $\overline{\Sigma 32}$ VERs obtained from control stimuli presented during the first and third of four control sessions. Columns labeled "2" refer to $\overline{\Sigma 64}$ VERs that are the mean of $\overline{\Sigma 32}$ VERs obtained from control stimuli presented during the second and fourth of four control sessions. Dates on which these control data were obtained are:

Subject K	Subject K
8/21/77	8/22/77
10/29/77	7/17/78
Subject JI	Subject JI
10/30/77	11/19/77
1/11/78	7/17/78
Subject JU	Subject JU
10/29/77	10/30/77
7/15/78	10/08/78

The first column labeld "f", under either "1" or "2", refers to frequency components at which the absolute value of amplitude differences between $\overline{\Sigma 64}$ VERs from unlike control stimuli were greater than 10% of the error range for that frequency given in Appendix B (error distributions). The columns labeled "D" give the absolute value of component frequency amplitude differences (in microvolts) for frequencies listed in the first column labeled "f." The column labeled "#" gives the number of frequency components for a particular comparison showing a difference, but below the 10% criterion (these frequency components are listed in the second column labeled "f" under either "1" or "2"). The control VERs compared in each table are:

1. Blank--no background and no figure
2. Background Only--background, but no figure
3. Figure--background and a partial circle, open at the base, for subjects K and JU, and the corners of a large square for subject JI.

The format of all the comparison tables is the same, differing only in subject and electrode position at which the control $\overline{\Sigma 64}$ VER comparisons are made.

TABLE C - 1

CONTROL DATA COMPARISONS

SUBJECT K ELECTRODE POSITION F_7

	1				2			
	f	D	f	#	f	D	f	#
Background only - Blank	1 4 7	0.73 0.26 0.27	5 13 14	3			6 10 15 18 20	5
Figure - Blank	1 4 7	0.73 0.75 0.32	5 6 9 10 25	5	3	0.50	1 7 12 23 29	5
Figure - Background only	15 9	0.29 0.28	10 12 13 29	4	3 7	0.25 0.28	2 12 20	3

ELECTRODE POSITION F_8

	f	D	f	#	f	D	f	#
Background only - Blank	4 5 7	0.25 0.46 0.44	6 8 19 20	4	4	0.22	7 15 22 24 27	5
Figure - Blank	1 4 5 6	0.43 0.45 0.37 0.42	9 12 17 18	4	1 3 4 5	0.46 0.28 0.25 0.30	7 9 22	3
Figure - Background only			4 5 17 19 20 28	6	7	0.23	3 8	2

TABLE C - 2

CONTROL DATA COMPARISONS

SUBJECT K ELECTRODE POSITION P_3

	1 f	1 D	1 f	1 #	2 f	2 D	2 f	2 #
Background only - Blank			5 9 18 19	4	1	0.43	28	1
Figure - Blank	1 3 4 5 9	0.90 0.95 0.99 0.21 0.32	7 14 18 21 25 29	6	1 2 3 4 5 8	0.53 0.43 0.91 0.68 0.33 0.67	12 16	2
Figure - Background only	1 2 3 4 7 9	0.35 0.23 0.69 0.99 0.25 0.21	5 17 25	3	3 8	0.66 0.52	16 19 20	3

ELECTRODE POSITION P_4

	1 f	1 D	1 f	1 #	2 f	2 D	2 f	2 #
Background only - Blank	2 5 13	0.28 0.23 0.12	3 17	2	1 14	0.65 0.15	2 4 5 ;2 13 19 20 21 22 23	10
Figure - Blank	1 3 4 5 11 15	1.13 1.75 0.95 0.87 0.23 0.12	9 14 21 24 25	5	1 2 3 4 5 8	1.39 0.31 1.26 1.46 0.62 0.30	7 9 11 13 14 16 19 24 26	9
Figure - Background only	3 4 5	1.23 0.90 0.51	8 2; 24 28	4	1 3 4 14 16	0.50 0.78 0.49 0.17 0.10	8 22	2

TABLE C - 3

CONTROL DATA COMPARISONS

SUBJECT K ELECTRODE POSITION O_1

	1				2			
	f	D	f	#	f	D	f	#
Background only - Blank	5	0.32	3 7 9 12 18 21 29	7	6 9	0.23 0.25	15 18 19 20 23 26	6
Figure - Blank	1 3 4 6	0.34 0.66 0.28 0.30	5 7 8 9 18 19 25 26	8	1 4 9	0.42 0.21 0.45	5 8 11 12 15 21 23	7
Figure - Background only	3 6 8	0.40 0.38 0.21	24 26 28	3	1 4 5 6 8	0.36 0.47 0.21 0.22 0.20	9 10 15 18 20 21 22 23	8

ELECTRODE POSITION O_2

	1				2			
	f	D	f	#	f	D	f	#
Background only - Blank	5	0.52	7 20 22	3	6 15	0.28 0.14	8 9 14 16 18 21 22 23	8
Figure - Blank	1 3 5 8 10 11	0.39 0.73 0.51 0.23 0.22 0.25	4 12 18 19 20	5	1 2 4 5 8 9 18 21	1.50 0.24 1.08 0.48 0.29 0.89 0.10 0.13	19 22 28	3
Figure - Background only	3 8	0.36 0.45	4 7 21 25 27 28	6	4 5 6 8 9	0.78 0.24 0.44 0.40 0.44	1 14 18 19 23 24	6

TABLE C - 4

CONTROL DATA COMPARISONS

SUBJECT JI ELECTRODE POSITION F_7

	1 f	1 D	1 f	1 #	2 f	2 D	2 f	2 #
Background only - Blank	3 4	0.27 0.27	8 13 14 16 22	5	1 6	1.91 0.13	2 3 7 17 19 23 28	7
Figure - Blank	1 10	0.88 0.11	5 8 14 29	4	1 6	1.24 0.12	2 7 8 17 21	5
Figure - Background only			7 13	2	14	0.11	17 27	2

ELECTRODE POSITION F_8

	1 f	1 D	1 f	1 #	2 f	2 D	2 f	2 #
Background only - Blank	1	0.37	3 10 16 18 26 29	6	1 2 4	1.00 0.38 0.23	8 16	2
Figure - Blank	1 6 7	0.33 0.15 0.23	16 17 25 28	4	1 4	1.54 0.60	5 8 13 26	4
Figure - Background only	6 7 10	0.22 0.24 0.13	18 23	2	4 5 13	0.28 0.16 0.12	6	1

TABLE C - 5

CONTROL DATA COMPARISONS

SUBJECT JI ELECTRODE POSITION P_3

	1 f	1 D	1 f	1 #	2 f	2 D	2 f	2 #
Background only - Blank	1	2.17	4	10	1	2.34	5	7
	2	0.44	7		3	0.60	9	
			8		6	0.12	12	
			9		11	0.31	19	
			10		13	0.17	22	
			11		18	0.20	24	
			12				27	
			13					
			22					
			28					
Figure - Blank	1	2.33	7	4	1	0.35	7	6
	4	0.73	22		2	0.37	9	
	5	0.39	24		3	0.77	16	
	8	0.23	25		4	0.43	22	
	9	0.12			10	0.33	24	
					11	0.21	27	
					13	0.36		
					14	0.34		
					15	0.12		
Figure - Background only	4	0.20	17	3	14	0.31	3	6
	5	0.28	25				6	
	12	0.11	28				13	
							18	
							19	
							22	

ELECTRODE POSITION P_4

	1 f	1 D	1 f	1 #	2 f	2 D	2 f	2 #
Background only - Blank	1	3.28	4	6	1	3.43	2	9
	2	0.28	13		8	0.12	4	
	8	0.27	14		9	0.23	7	
	10	0.11	17		10	0.47	14	
	11	0.15	21		11	0.44	15	
	12	0.12	26		12	0.45	16	
					13	0.12	22	
					18	0.18	24	
					20	0.15	29	
Figure - Blank	1	3.10	2	7	1	2.33	15	6
	4	0.36	8		2	0.39	16	
	7	0.12	14		3	0.40	23	
			15		4	0.34	25	
			20		8	0.12	26	
			28		9	0.21	27	
			29		10	0.29		
					11	0.38		
					12	0.34		
					13	0.15		
					14	0.15		
					17	0.15		
Figure - Background only	4	0.18	2	5	2	0.51	4	4
	8	0.17	7		10	0.11	6	
	13	0.10	12		18	0.16	21	
			14				25	
			22					

TABLE C - 6

CONTROL DATA COMPARISONS

SUBJECT JI ELECTRODE POSITION O_1

	1				2			
	f	D	f	#	f	D	f	#
Background only - Blank	1 2 3	1.31 0.27 0.12	6 7 9 12 13	5	1 2 12 13	2.02 0.39 0.20 0.11	6 11 18 23	4
Figure - Blank	2 6 9	0.61 0.30 0.14	1 3 16 20 23 28	6	4 10 11 12	0.13 0.17 0.22 0.11	2 3 13 16 28	5
Figure - Background only	6 12 15	0.17 0.17 0.10	9 16 22 25	4	7	0.23	2 3 4 14 18 19 27 29	8

ELECTRODE POSITION O_2

	f	D	f	#	f	D	f	#
Background only - Blank	1 2 6 9 12	1.66 0.29 0.14 0.11 0.21	11 14 18 28	4	1 2 10 11 12	1.60 0.46 0.17 0.20 0.28	6 13 15 16 17 18 22	7
Figure - Blank	1 2 4	0.46 0.40 0.17	5 9 21 22	4	2 3 10 11 12 16	0.36 0.27 0.14 0.22 0.17 0.14	9 14 23 24 27	5
Bigure - Background only	12	0.31	13	1	3	0.42	12 17 22 27	4

TABLE C - 7

CONTROL DATA COMPARISONS

SUBJECT JU ELECTRODE POSITION F_7

	1				2			
	f	D	f	#	f	D	f	#
Background only - Blank	2	o.23	11		3	0.20	1	
	5	0.14	12		4	0.17	2	
	7	0.13	13		18	0.10	11	
	8	0.15	16	4	21	0.10		3
					26	0.39		
Figure - Blank	2	0.74	6		2	0.46	5	
	3	0.35	11		3	0.47	21	
	4	0.37	22		4	0.20		
	5	0.21	24	5	9	0.21		2
	17	0.11	27					
Figure - Background only	2	0.27	4		3	0.22	5	
	3	0.52	7		4	0.41	18	
	20	0.10	16		8	0.12		
			22	5	17	0.10		2
			28		26	0.13		

ELECTRODE POSITION F_8

	1				2			
	f	D	f	#	f	D	f	#
Backround only - Blank	1	1.08	6		2	0.22	7	
	4	0.13	7		6	0.17	8	
	5	0.28	9		9	0.13	13	
	8	0.14	12	7	16	0.10	20	4
	15	0.10	21		24	0.15		
	16	0.15	26					
	23	0.17	28					
Figure - Blank	2	0.28	8		1	0.31	8	
	3	0.73	9		3	0.17	9	
	4	0.61	22		4	0.75	12	
	5	0.21		3	5	0.20	16	5
	7	0.15					20	
	12	0.17						
	15	0.16						
	26	0.32						
	27	0.18						
Figure - Background only	1	0.43	2		17	0.11	5	
	3	0.50	22				7	
	4	0.25		2			16	
	26	0.18					20	7
							24	
							26	
							29	

TABLE C - 8

CONTROL DATA COMPARISONS

SUBJECT JU ELECTRODE POSITION P_3

	1				2			
	f	D	f	#	f	D	f	#
Background only - Blank	1	0.47	2	6	2	0.39	8	5
	4	0.37	9		6	0.17	13	
	5	0.20	12		12	0.18	18	
	6	0.25	19				22	
	7	0.25	21				25	
	8	0.17	25					
Figure - Blank	1	0.37	3	7	4	0.15	7	2
	2	0.33	4		6	0.15	29	
	6	0.25	11					
	7	0.22	16					
			17					
			26					
			29					
Figure - Background only	4	0.11	2	11	12	0.26	13	3
	11	0.12	16				22	
			17				29	
			18					
			19					
			21					
			22					
			25					
			26					
			28					
			29					

ELECTRODE POSITION P_4

	f	D	f	#	f	D	f	#
Background only - Blank	1	0.93	11	4	1	0.98	3	6
	3	0.50	13		2	0.45	7	
	4	0.43	20		5	0.41	8	
	5	0.55	25		6	0.30	9	
	6	0.31			13	0.29	14	
	7	0.25			16	0.20	15	
	8	0.33						
	12	0.40						
	18	0.11						
Figure - Blank	3	0.52	6	5	1	0.77	3	5
	4	0.43	9		2	0.34	7	
	5	0.35	22		4	0.43	15	
	7	0.31	23		5	0.28	19	
	11	0.14	25		6	0.11	27	
	12	0.12						
	14	0.14						
Figure - Background only			5	8	6	0.12	2	4
			9		13	0.28	9	
			10		18	0.11	21	
			18				27	
			20					
			23					
			28					
			29					

TABLE C - 9

CONTROL DATA COMPARISONS

SUBJECT JU ELECTRODE POSITION O_1

	1 f	1 D	1 f	1 #	2 f	2 D	2 f	2 #
Background only - Blank	1 2 4 6 7 8 13	1.28 0.44 0.28 0.15 0.16 0.31 0.22	17 18 20 29	4	11	0.12	2 3 5 12 13 18 22 29	8
Figure - Blank	1	0.50	2 5 6 7 8 17 22 26	8	1 3 6 7 8 10 11	0.43 0.18 0.29 0.14 0.20 0.11 0.12	9 13 22 29	4
Figure - Background only	3	0.14	2 5 11 12 18 20 28 29	8	6 8	0.24 0.15	7 12 13 14 22 29	6

ELECTRODE POSITION O_2

	1 f	1 D	1 f	1 #	2 f	2 D	2 f	2 #
Backround only - Blank	1 2 4 10 11	0.55 0.29 0.24 0.11 0.12	5 6 7 8 12 20 23 29	8	2 13	0.44 0.17	1 5 6 7 15 22 27	7
Figure - Blank	3 4 5 7 10	0.51 0.21 0.13 0.18 0.12	2 6 8 11 14 15 17 21 23 29	10	1 3 6 7	0.61 0.34 0.15 0.21	8 13 15 19 20 29	6
Figure - Background only	29	0.11	7 12 20 28	4	3 13	0.34 0.23	6 7 18 19 23 25 29	7

APPENDIX D

Geometrical Figure Comparisons

Tables D-1 through D-18 give the Fourier frequency components (f, in Hz) at which $\overline{\Sigma 64}$ VERs obtained from unlike geometrical figures were different. Difference was determined when the absolute value of the difference between corresponding frequency component amplitudes in two different $\overline{\Sigma 64}$ VERs was greater than the absolute value of the difference between the same corresponding frequency amplitudes in both the first $\overline{\Sigma 32}$ VER and its replication, making up the $\overline{\Sigma 64}$ VER from the first stimulus and the second $\overline{\Sigma 32}$ VER and its replication, making up the $\overline{\Sigma 64}$ VER from the second stimulus.

The first, third and fifth columns labeled "f" refers to frequency components at which the absolute value of amplitude differences between $\overline{\Sigma 64}$ VERs from unlike geometrical figures were greater than 10% of the error range for that frequency given in Appendix B (error distributions). The columns labeled "D" give the absolute value of component frequency amplitude differences (in microvolts) for frequencies listed in the first, third and fifth columns labeled "f." The columns labeled "#" give the number of frequency components for a particular comparison showing a difference, but below the 10% criterion (these frequency components are listed in the second, fourth and sixth columns labeled "f"). The geometrical figure $\overline{\Sigma 64}$ VERs compared are:

ST-SS... small triangle - small square

ST-SP... small triangle - small pentagon

ST-SO... small triangle - small circle

SS-SP... small square - small pentagon

SS-SO... small square - small circle

SP-SO... small pentagon - small circle

LT-LS... large triangle - large square

LT-LP... large triangle - large pentagon

LT-LO... large triangle - large circle

LS-LP... large square - large pentagon

LS-LO... large square - large circle

LP-LO... large pentagon - large circle

ST-LT... small triangle - large triangle

SS-LS... small square - large square

SP-LP... small pentagon - large pentagon

SO-LO... small circle - large circle

The format of all the comparison tables is the same, differing only in subject and electrode position at which the geometrical figure comparisons are made.

$\overline{\Sigma 64}$

TABLE D - 1

SUBJECT K ELECTRODE POSITION F_7

	f	D	f	#
ST-SS			2 6 9 17 18 19 20 22 24 25 27	11
ST-SP	22	0.15	9 11 17 18 26	5
ST-SO	22	0.13	1 6 8 9 10 17 18 24 25	9
SS-SP	3	0.44	1 12 25	3
SS-SO	1	0.44	3 12 15 19 21	5
SP-SO	7 16	0.26 0.11	15 25	2

	f	D	f	#
LT-LS	5 8	0.55 0.73	3 11 12 25	4
LT-LP			5 22	2
LT-LO	7	0.20	4 6 12	3
LS-LP	8	0.22	13 19	2
LS-LO			3 13 19 25	4
LP-LO	4	0.34 0.33	3 20 22	3

	f	D	f	#
ST-LT	5 22	0.30 0.13	3 11 19 20	
SS-LS	25	0.11	3 5	
SP-LP			7 9 15 16 22	
SO-LO	4 7	0.40 0.57	3 12 17	

TABLE D - 2

SUBJECT K ELECTRODE POSITION F_8

	f	D	f	#
ST-SS	6 9 16	0.35 0.28 0.17	5 13 23	3
ST-SP	6	0.47	1 23 29	3
ST-SO	1 9 21	0.38 0.35 0.11	5 6 8 18 23	5
SS-SP	16	0.12	3 4 5 6 19 22	6
SS-SO	5 6 18	0.23 0.45 0.11	3 4 13 17 21 22 23 24	8
SP-SO	6	0.59	9 11	2

	f	D	f	#
LT-LS	5	0.25	6 10 14 15 16 22 29	7
LT-LP			10 12	2
LT-LO	7	0.34	3 6 26	3
LS-LP			12 16 28	3
LS-LO	10	0.38	6 12 15 28 29	5
LP-LO	10	0.41	4 12	2

	f	D	f	#
ST-LT			3 5 6 7 14 16 23	7
SS-LS			3 14 18 19 22	5
SP-LP	10	0.50	1 11 19 29	4
SO-LO	6	0.61	7 9 13 26	4

TABLE D - 3

SUBJECT K ELECTRODE POSITION P_3

	f	D	f	#
ST-SS	10	0.40	4 18	2
ST-SP			12 15 20 23	4
ST-SO	4 18	0.33 0.14	11	1
SS-SP	3	0.23	12 18 20	3
SS-SO	3	0.40	10 16 17 18 29	5
SP-SO	17	0.10	3 5 11 12 18 21 23 29	8

	f	D	f	#
LT-LS	6 7 8 10	0.23 0.36 0.39 0.26	1 11 16 23 25	5
LT-LP	4 23	0.29 0.12	16 17	2
LT-LO	7 23	0.29 0.15	6 16 17 18 26 27 29	7
LS-LP	10	0.29	11 17 26	3
LS-LO			10 17 24 26	4
LP-LO			2 24 27	3

	f	D	f	#
ST-LT	4 10 23	0.32 0.32 0.18	18 22	2
SS-LS	7	0.36	10 12 17	3
SP-LP			7	1
SO-LO	3 18	0.38 0.10	7 17 24 29	4

TABLE D - 4

SUBJECT K ELECTRODE POSITION P_4

	f	D	f	#
ST-SS	2 4	0.30 0.20	19 26 29	#
ST-SP			2 4 8 23	4
ST-SO	2 4	0.34 0.31	1 8 17 18 21 27 29	7
SS-SP			2 11 20	3
SS-SO	2 11 12	0.79 0.28 0.30	3 8 13 17 18 21 29	7
SP-SO	2 9	0.50 0.21	4 12 13 18 27	5

	f	D	f	#
LT-LS	4	0.24	2 6 16 27	4
LT-LP			2 4 6 7 13 20 23 25 28	9
LT-LO	2 3 25	0.46 0.36 0.12	4 8 20 23	4
LS-LP			6 9 14 24	4
LS-LO			2 6 7 9 16 18	6
LP-LO	9	0.48	3	1

	f	D	f	#
ST-LT	2 4	0.23 0.36	6 16 21 23 26	5
SS-LS	2	0.28	4 21	2
SP-LP	9	0.50		0
SO-LO			4 7 12 17 18 29	6

TABLE D - 5

SUBJECT K ELECTRODE POSITION O_1

	f	D	f	#
ST-SS	1	0.52	4 5 11	3
ST-SP	1 4 5	1.13 0.34 0.28	17 20 24 25	4
ST-SO	1 4	0.94 0.60	2 5 20	3
SS-SP			7 11 13 20 25	5
SS-SO	2	0.40	3 10 11 13 16 22	6
SP-SO	2 3	0.27 0.26	1 4 5 24 28	5

	f	D	f	#
LT-LS			4 5 7 16 18 22	6
LT-LP	3 5 10 23	0.39 0.25 0.38 0.11	1 13 14 16 17 18 19 21 22	9
LT-LO			5 15 23	3
LS-LP	3 5 10 17	0.39 0.34 0.21 0.11	1 13 14 18	4
LS-LO	2 5	0.22 0.24	15 17 25	3
LP-LO	3	0.30	2 5 17 19 25	5

	f	D	f	#
ST-LT	1 4 6	0.86 0.56 0.39	22 23	2
SS-LS	7	0.20	5 13 18 26	4
SP-LP	3 6	0.26 0.32	5 13 17 23 25	5
SO-LO	2 3	0.70 0.30	21 24	2

TABLE D - 6

SUBJECT K - ELECTRODE POSITION O_2

	f	D	f	#		f	D	f	#		f	D	f	#
ST-SS			4 11 13 16 22 26	6	LT-LS	4	0.27	5	1	ST-LT	4 6	0.37 0.27	1 13 19 22 26	5
ST-SP	1	0.42	4 5 19 26	4	LT-LP			3 5 11 15 19 20 21 22 26 28	10	SS-LS				0
ST-SO	1 4 5	0.34 0.29 0.23	2 14 21 26	4	LT-LO	1 5	0.91 0.30	3 15 19	7	SP-LP			3 18 19 22 23	5
SS-SP	11	0.29	13 14 16 22 26	5	LS-LP	1	0.46	8 24	3	SO-LO			2 5 9 20 21 24 26	7
SS-SO			1 5 7 11 14 16 21 23 25 26	10	LS-LO	3	0.37	20 23 27	2					
SP-SO	7	0.22	5 25	2	LP-LO			1 8 11 14 17 22 26	7					

TABLE D - 7

SUBJECT JI ELECTRODE POSITION F_7

	f	D	f	#
ST-SS	10 25	0.14 0.12	23 24	2
ST-SP			7 19 24	3
ST-SO	1 6	0.35 0.20	7 8 14 20 21 26 29	7
SS-SP	25	0.14		0
SS-SO	4 6 25	0.19 0.38 0.16	2 7 15 20 23 24 25 28	8
SP-SO	1	0.45	2 16 21 24	4

	f	D	f	#
LT-LS	6 14	0.21 0.10	3 7 9 10 13 19 20 22 29	9
LT-LP			2 6 13 14 15 20	6
LT-LO			13 19 25 29	4
LS-LP	10	0.12	3 9 13 19 26 27	6
LS-LO	10	0.14	17 20	2
LP-LO			13 15 19 20 25 26	6

	f	D	f	#
ST-LT	9 13	0.25 0.11	2 7 8 10 12	5
SS-LS	6 7 10 20	0.21 0.20 0.20 0.12	3 27 29	3
SP-LP	9 26	0.30 0.11	1 2 6 19 25	5
SO-LO	7	0.22	13 20 25 29	4

TABLE D - 8

SUBJECT JI ELECTRODE POSITION F_8

	f	D	f	#		f	D	f	#		f	D	f	#
ST-SS			3 7 8 9 11 13 20	7	LT-LS	7	0.28	6 8 9 11 18 22 24 25	8	ST-LT			3 7 11 14 25 27	6
ST-SP	3 25	0.29 0.14	13 28	2	LT-LP			1 14 15 27	4	SS-LS	7 8	0.27 0.16	2 8 12 18 21 23	6
ST-SO	1 8	0.37 0.12	2 3 11 14 17 25 28	7	LT-LO	6	0.11	10 11 12 19	4	SP-LP				0
SS-SP	10 12	0.17 0.13	7 27	2	LS-LP	11 20 24	0.12 0.11 0.10	2 4 6 9 16 21	6	SO-LO	2	0.43	7 10 11 12 20 24 28	7
SS-SO	2	0.22	12 20	2	LS-LO	24	0.19	7 8 9 12	4					
SP-SO	12	0.16	1 3 10	3	LP-LO	6	0.17	11 16 20	3					

TABLE D - 9

SUBJECT JI ELECTRODE POSITION P_3

	f	D	f	#
ST-SS			2 16 17 27	4
ST-SP	2 11	0.31 0.18	13 14 16 29	4
ST-SO	13	0.18	2 6 23 27	4
SS-SP	10 29	0.12 0.10	3 5 13	3
SS-SO	5 6 10	0.12 0.35 0.29	11 16 17 18 24 29	6
SP-SO			10 12 16 18	4

	f	D	f	#
LT-LS	4	0.20	11 13 22 23 28	5
LT-LP	3 7 10 11 13	0.20 0.14 0.21 0.20 0.21	14 20 21	3
LT-LO	4 9	0.35 0.12	2 12 24 29	4
LS=LP			2 3 7 10 11 13 20 28	8
LS-LO			2 24 27 28	4
LP-LO	5 19	0.21 0.11	9 28	2

	F	D	f	#
ST-LT	4 7	0.23 0.14	2 3 16 23	4
SS-LS	10	0.21	1 8 16 17 28	5
SP-LP	29	0.13		0
SO-LO	5 6	0.58 0.22	18 27 29	3

TABLE D - 10

SUBJECT JI ELECTRODE POSITION P_4

	f	D	f	#
ST-SS			1 23 27	3
ST-SP	9 20	0.18 0.15	2 13 15 16 22 23 25	7
ST-SO	6 9	0.12 0.11	19 23 27	3
SS-SP	1 5 20	0.42 0.11 0.17	2 11 15 27	4
SS-SO	5	0.25	6 12 19	3
SP-SO	1 20	0.37 0.17	2 27	2

	f	D	f	#
LT-LS	4 14	0.20 0.10	9	1
LT-LP	7 11 17	0.14 0.15 0.12	12	1
LT-LO	4 9 11	0.20 0.41 0.11	6 16 17 23 25	5
LS-LP	14	0.14	4 10 12 18 24	5
LS-LO			16	1
LP-LO			4 12 16 17	4

	f	D	f	#
ST-LT			2 4 16 17 23	5
SS-LS	1	0.40	12 18 23 24 28	5
SP-LP			14 15 16 17 20	5
SO-LO	6 9	0.30 0.11	11 26	2

TABLE D - 11

SUBJECT JI ELECTRODE POSITION O_1

	f	D	f	#
ST-SS			9	1
ST-SP	11	0.20	2 10 15 21 29	5
ST-SO	6	0.19	22 24	2
SS-SP			3 5 10 11 13 21	6
SS-SO	5 10 18	0.32 0.14 0.18	8 9	2
SP-SO	2 5 10 11 12 13	0.33 0.27 0.30 0.20 0.12 0.11	18 29	2

	f	D	f	#
LT-LS	14	0.11	4 11 12 13 27	5
LT-LP	4 11 13 14	0.25 0.17 0.14 0.25	3 6 27	3
LT-LO	4 6 9 12	0.28 0.17 0.15 0.14	3 23 27 29	4
LS-LP	4	0.11	3 11 14	3
LS-LO	3 4 10	0.25 0.13 0.17	9 29	2
LP-LO			6 9 16	3

	f	D	f	#
ST-LT	4 8	0.28 0.14	7 14 19	3
SS-LS	3	0.30	8 10	2
SP-LP	2	0.38	5 21 29	3
SO-LO	6 7 9 10	0.40 0.11 0.14 0.32	12 18 29	3

TABLE D - 12

SUBJECT JI ELECTRODE POSITION O_2

	f	D	f	#
ST-SS			5 15 19 27	4
ST-SP	2 9 11 ~~15~~	0.25 0.11 0.36 ~~0.12~~	12 17 25	3
ST-SO			6 18 21	3
SS-SP	11	0.45	2 15 16 19 23 26 27	7
SS-SO	5	0.11	6 8 19	3
SP-SO	2 11	0.41 0.44	6 9 10 12 16 18	6

	f	D	f	#
LT-LS			9 18 23 29	4
LT-LP	8 13 14	0.12 0.11 0.12	6 7 11	3
LT-LO	6	0.13	9 11	2
LS-LP			4 14 18 23 25	5
LS-LO	10	0.27	4 11 18 19 23	5
LP-LO			4	1

	f	D	f	#
ST-LT	5	0.18	2 8 14 25	4
SS-LS	8	0.12	3 10 19 23	4
SP-LP	11	0.25	2 9 12 22 23	5
SO-LO	5 6 7 10	0.22 0.25 0.20 0.25	4 11 18	3

TABLE D - 13

SUBJECT JU ELECTRODE POSITION F_7

	f	D	f	#
ST-SS	13	0.25	11 12 17 20 22 23 25 27	8
ST-SP	13 15	0.12 0.12	10 22 23 26	4
ST-SO	13 17	0.19 0.15	7 14 23 26 29	5
SS-SP	12 19 20	0.11 0.19 0.10	10 11 13 15 25 26 28	7
SS-SO	4 19 20 23 25	0.18 0.14 0.21 0.14 0.12	7 13 22 26 27 28 29	7
SP-SO	15 23	0.12 0.15	3 10 13 17 21 22 29	7

	f	D	f	#
LT-LS	1 15 21 27	0.33 0.10 0.13 0.19	2 6 10 14 28	5
LT-LP	3 5 28	0.46 0.14 0.17	2 16 21 22 29	5
LT-LO			4 10 17	3
LS-LP	5 11 27	0.18 0.17 0.15	6 8	2
LS-LO	4 12	0.14 0.16	6 8 10 11 14 21	6
LP-LO			14 21	2

	f	D	f	#
ST-LT	13 15 17	0.12 0.13 0.18	2 10 18 22 27	5
SS-LS	3 5 12 22 25 28	0.12 0.20 0.12 0.19 0.12 0.13	27	1
SP-LP	8 11 15	0.11 0.19 0.11	22	1
SO-LO	26	0.11	8 14 20 21 22 23	6

TABLE D - 14

SUBJECT JU ELECTRODE POSITION F_8

	f	D	f	#
ST-SS	9 12 24	0.14 0.15 0.10	5 15	2
ST-SP	12 17	0.14 0.17	25	1
ST-SO	17	0.15	5 9 15 24 25 29	6
SS-SP	25	0.14	1 13 16 19 27	5
SS-SO	5 9	0.22 0.30	4 7 25	3
SP-SO			4 13 20	3

	f	D	f	#
LT-LS			2 3 4 11 24 25 26 28	8
LT-LP	3 5 28	0.46 0.14 0.17	2 16 21 22 29	5
LT-LO	4 27	0.11 0.12	3 22 26 29	4
LS-LP	1 18 21	0.88 0.10 0.17	2 7 11 13 25	5
LS-LO	1 4 11 25	0.52 0.27 0.24 0.13	7 12 15 18 23 24 27 29	8
LP-LO	11	0.14	3 15 16 27	4

	f	D	f	#
ST-LT	3	0.20	2 12 24 29	4
SS-LS	1 9 25	0.37 0.20 0.19	11 12 13 15	4
SP-LP	1 16	0.70 0.17	13 15 17	3
SO-LO	13	0.12	8 ;8 26 29	4

TABLE D - 15

SUBJECT JU ELECTRODE POSITION P_3

	f	D	f	#
ST-SS			6 9 18 19	4
ST-SP	3 12	0.52 0.16		0
ST-SO	2	0.47	7 14 17	3
SS-SP	3	0.30	4 5 6 9 14 16 19	7
SS-SO	2	0.35	4 8 12 13 14 15 17 20 21 25	10
SP-SO	3 12 17	0.22 0.19 0.10	5 6 8 15	4

	f	D	f	#
LT-LS	2 4 14	0.22 0.14 0.16		0
LT-LP	5	0.19	14 27 29	3
LT-LO	4 5	0.19 0.12	2 10 12 14 19 22 27 29	8
LS-LP	1	0.34	9 11 17 18 25	5
LS-LO	2 14	0.30 0.28	9 10 11 12 27	5
LP-LO	14 17	0.22 0.13	8 9 12 20 25	5

	f	D	f	#
ST-LT	2 7	0.21 0.12	5 12 14 20 27	5
SS-LS	3 7 0.12	0.24	6 11 22	3
SP-LP	1 5 17	0.58 0.13 0.12	9 14 16 18 27	5
SO-LO	13 17 20	0.34 0.11 0.13	2 14 22 23	4

TABLE D - 16

SUBJECT JU ELECTRODE POSITION P_4

	f	D	f	#
ST-SS	7 14	0.13 0.10	11 18	2
ST-SP	3 5 11	0.21 0.13 0.17	9 10	2
ST-SO	10 17	0.14 0.14	3 4 5	3
SS-SP	3 7 8	0.12 0.13 0.12	18 25	2
SS-SO	4 7 14	0.17 0.16 0.16	11 18 20 22	4
SP-SO	4 8 11 12	0.14 0.11 0.15 0.38	1 3 20 23	4

	f	D	f	#
LT-LS	10 20	0.11 0.12	13 22 23 24	4
LT-LP			10 20 22 23 24	5
LT-LO	13	0.10	7 20 23	3
LS-LP			1 7 8 13 21 22 24 26 29	9
LS-LO	2	0.33	1 7 10 11 13 21 22 26	8
LP-LO	1 13	0.46 0.11	10 14 19	3

	f	D	f	#
ST-LT			7 18 20 24 25	5
SS-LS	6	0.11	3 8 22 26	4
SP-LP	1	0.71	3 8 11 12 21 25 26	7
SO-LO	23	0.10	10 14 17	3

TABLE D - 17

SUBJECT JU ELECTRODE POSITION O_1

	f	D	f	#
ST-SS	6	0.11	3 4 19 24 28	5
ST-SP	3	0.16	12 26	2
ST-SO	13	0.12	18 19 24	3
SS-SP	1 4	0.25 0.32	2 6 21 23 24	5
SS-SO	4	0.37	3 21 25	3
SP-SO	8 12	0.11 0.24	2 3 4 17 18 24 25	7

	f	D	f	#
LT-LS	3 8	0.23 0.30	5 6 14 21 27	5
LT-LP			8 25 29	3
LT-LO	5 6	0.15 0.12	4 11 14 21 22	5
LS-LP	8	0.42	12 21 25 29	4
LS-LO	8	0.24	2 5 11 14	4
LP-LO			12 14 22 29	4

	f	D	f	#
ST-LT	11	0.15	6 24 26 27	4
SS-LS	6 8	0.18 0.17	1 2 4 11 21 24	6
LP-LP			9 22 24 29	4
SO-LO	4	0.24	6 13 14 17 22 23 25 26	8

TABLE D - 18

SUBJECT JU ELECTRODE POSITION O_2

	f	D	f	#
ST-SS			3 4 8 19	4
ST-SP	3 24	0.14 0.11	14 22 26	3
ST-SO	2	0.46	8 11 17 19 22	5
SS-SP	4	0.20	8 14 18 24	4
SS-SO	2 4	0.35 0.32	11 18 25	3
SP-SO	2 24	0.50 0.13	4 5 8 12 20 26	6

	f	D	f	#
LT-LS	3 18	0.43 0.11	7 11 16 17 19 21 27	7
LT-LP			8 11 16	3
LT-LO			2 9 11 13 16 22 29	7
LS-LP	19	0.10	5 6 17 18 21 25 27	7
LS-LO	5 11 14 18	0.13 0.19 0.14 0.13	1 2 19 20 21 27	6
LP-LO	13	0.25	1 14 22 26 28 29	6

	f	D	f	#
ST-LT			23 29	2
SS-LS	3 19	0.21 0.10	1 4 11 18 21 25 27	7
SP-LP	14	0.10	1 21 22 24 29	5
SO-LO	4 22	0.19 0.10	2 5 11 13 25 26	6

APPENDIX E

Trigram Comparisons

Tables E-1 through E-6 give the Fourier frequency components (F, in Hz) at which $\overline{\Sigma 64}$ VERs obtained from unlike trigrams were different. Difference was determined when the absolute value of the difference between corresponding frequency component amplitudes in two different $\overline{\Sigma 64}$ VERs was <u>greater</u> than the absolute value of the difference between the same corresponding frequency amplitudes in <u>both</u> the first $\overline{\Sigma 32}$ VER and its replication, making up the $\overline{\Sigma 64}$ VER from the first stimulus, <u>and</u> the second $\overline{\Sigma 32}$ VER and its replication, making up the $\overline{\Sigma 64}$ VER from the second stimulus.

The first, second and third sets of columns refer to data obtained from subjects K, JI and JU respectively. The first column labeled "F" under each of the subject labels refers to frequency components at which the absolute value of amplitude differences between $\overline{\Sigma 64}$ VERs from unlike trigram stimuli were <u>greater</u> than 10% of the error range for that frequency given in Appendix B (error distributions). The columns labeled "D" give the absolute value of component frequency amplitude differences (in microvolts) for frequencies listed in the first column labeled "F" under each subject heading. The column labeled "#" gives the number of frequency components for a particular comparison showing a difference, but below the 10% criterion. (These frequency components are listed in the second column labeled "F" under each of the subject headings.)

The trigram VERs compared in each table are:

WAR-RAW

WAR-AWR

WAR-RWA

RAW-AWR

RAW-RWA

AWR-RWA

The format of all comparison tables (E-1 through E-6) is the same, differing only in electrode position at which the trigram comparisons are made.

Tables E-7 and E-8 provide the same type of information as the preceding tables except that all data is from subject JU, each set of columns refers to a different electrode position, and a different set of trigram $\overline{\Sigma 64}$ VERs is compared:

ART-RAT

ART-ATR

ART-RTA

RAT-ATR

RAT-RTA

ATR-RTA

TABLE E-1

Electrode Position F_7

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
WAR- RAW	9	0.21	8 11 12 14 22 23	6		12	0.21	19 23 26	3		8 11 19 27	0.21 0.20 0.10 0.19	1 7 9 12 13 24	6
WAR- AWR	16	0.12	4 5 8 12 13 14 26	7		6	0.19	5 25	2		23	0.10	6 26 27	3
WAR- RWA	4	0.23	11 14 25 26	4		2 3 5 6 19 23	0.52 0.19 0.35 0.12 0.33 0.27	26	1		7 11 16 26	0.21 0.23 0.15 0.26	9 13 15	3
RAW- AWR	8	0.23	12 19 22 26	4				4 5 12 14 17	5		8 10 27	0.33 0.22 0.10	1 9 21	3
RAW- RWA			2 11 14 15 18 25 26	7		4 5 19 23	0.19 0.17 0.25 0.15	2 3 10 12 17 22	6		10 12 16 27	0.20 0.12 0.20 0.20	7 11 24 26	4
AWR- RWA	16	0.19	11 13 26	3		19	0.19	4 7 22	3		6	0.28	11 15 23 25 27 28	6

TABLE E-2

Electrode Position F_8

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
WAR- RAW	4	0.52	3 8 15 18 22 25 28	7				12 15 16 18 26 29	6		5 7 8 9	0.56 0.47 0.21 0.11	2 16	2
WAR- AWR	10 19	0.27 0.15	1 4 5 18 23	5		9 16	0.18 0.19	6 8 12 14 23 29			17 22	0.16 0.14	7 19 28	3
WAR- RWA	16	0.10	2 4 19 21	4		3 4 6	0.41 0.15 0.44	10 24	2		5 7 13	0.39 0.21 0.35	6 8	3
RAW- AWR	10	0.20	5 7 18 20 26 28 29	7		8 16 21 23	0.14 0.17 0.15 0.11	6 27 29	3		2 7 8 10 22	0.31 0.42 0.28 0.17 0.34	14 23 27	3
RAW- RWA			9 20 22 25 27	5		3 4 6	0.46 0.40 0.43	1 10 12 17	4		2 10 13	0.40 0.21 0.34	5 7 8 12	4
AWR- RWA			13 19 27	3		3 4 16 27	0.48 0.42 0.14 0.13	11 12 29	3		7	0.17	14 29	2

TABLE E-3

Electrode Position P_3

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
WAR- RAW	9 10	0.39 0.21	7 11 19	3		10 12 13	0.11 0.27 0.16	17	1		9 13 21	0.23 0.11 0.11	8 15 18 19 22 28	6
WAR- AWR	4 9 16	0.29 0.69 0.10	5 11 20	3		4 5 10 11 12	0.23 0.19 0.14 0.20 0.17	3 7 13 17 29	5		13	0.12	1 3 5 6 9 10 17 25	8
WAR- RWA	25	0.12	5 7 16 22 29	5		12 13	0.22 0.22	10	1		3 10	0.13 0.14	2 22	2
RAW- AWR	16	0.12	4 5 7 23	4				1 3 9 12 24 25	6		9 21	0.13 0.14	2 7 11 19 24 26	6
RAW- RWA	9 23	0.27 0.13	5 6 16 24					18 24 28					15 22 28	
AWR- RWA	9 23	0.40 0.10	4 6 7 16 24	5		3	0.24	7 9 18 25	4		3	0.22	2 21	2

TABLE E-4

Electrode Position P_4

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
WAR-RAW	16	0.12	6 11 13 23	4		7 12	0.22 0.17	9 11 13 17 26	5		6	0.18	7 10 11 17 18 19 21 22	8
WAR-AWR	9	0.95	11 14 15 16 18 23 25	7		5 6 9 11	0.14 0.19 0.11 0.37	1 7 17 18 26 29	6		10 19	0.16 0.11	6 17	2
WAR-RWA	5 10 11 16	0.63 0.10 0.10	14 28	3		7 9	0.12 0.12	6 11 12 13 14 15 22	7		4 25	0.13 0.10	1 10 16 21 24 26	6
RAW-AWR	8 15 23	0.63 0.10 0.10	14 28	2		4 8 12 17	0.24 0.38 0.18 0.14	1 5 7 13 15 18 21 23	8		7	0.14	10 19 26	3
RAW-RWA	5 6	0.22 0.26	8 17 22 23	4		8 17 21	0.26 0.10 0.14	4 12 15 22 23	5				9 18 22 26	4
AWR-RWA	8	0.29	10 11 17	3		15	0.13	6 13 14	3				2 4 15	3

RABLE E-5

Electrode Position 0_1

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
WAR-RAW	10	0.27	2 5 9 11 12 16 20 26 28	9		12 13 17	0.14 0.17 0.17	7 10 19 22 24 26	6		8 13	0.11 0.12	16 17 21 22 27 28	6
WAR-AWR	4 9 16	0.37 0.46 0.10	6 7 22	3		8 10 11 22	0.17 0.19 0.25 0.14	1 4 25 26	4		6 10 16	0.14 0.33 0.10	17 21	2
WAR-RWA			11 19 25 27 29	5		10 11 12 18	0.18 0.15 0.13 0.10	2 4 7 22 25	5		9 13	0.20 0.29	12 16 22	3
RAW-AWR	4 8	0.40 0.32	3 9 12 13 26	5		17	0.13	12 13 15 16 21 22 24	7		3 8 10	0.12 0.15 0.16	5 15 16 27	4
RAW-RWA	9	0.28	2 5 16 19 20 28	6		7	0.21	17 21 24	3		8 9 12	0.13 0.21 0.30	13	1
AWR-RWA	4 7 9	0.45 0.31 0.41	16 25	2		4	0.21	11 12 13 16 22	5		3 4 9	0.18 0.41 0.19	21	1

TABLE E-6

Electrode Position 0_2

K JI JU

	F	D	F	#		F	D	F	#		F	D	F	#
WAR- RAW	9	0.21	5 8 11 16 19 21 23 28	8		11	0.16	1 7 10 12 13 24 27	7		5 6 13	0.15	8 11 18	3
WAR- AWR	9	0.62	7 27	2		8 10 11	0.12 0.14 0.32	1 19 25 27	4				6 10 13 17 25	5
WAR- RWA	2 11	0.20 0.23	24	1		10 11	0.12 0.12	13 19 26 27 29	5		13	0.23	4 9 11 17 21 25	6
RAW- AWR	7	0.20	8 9	2				6 7 12 13 16 19 22 23 24 25	10				4 8 19	3
RAW- RWA			2 4 5 11 18 25 28	7		4	0.14	1 3 7 16 19 22 29	7		2 11 18	0.48 0.34 0.12	21	1
AWR- RWA			4 7 25	3		4 11 13	0.13 0.11 0.11	22 25	2		2	0.42	4 9 21	3

TABLE E-7

Subject JU

	F_7					F_8					P_3			
	F	D	D	#		F	D	F	#		F	D	F	#
ART- RAT	17	0.15	18 21	2		3 7 16 24	0.28	12	3		3 11 16	0.31 0.17 0.11	1 21 27 29	4
ART- ATR	11	0.23	7 25	2		3 7	0.33 0.37	10 16 18 20 22	5		2 16	0.20 0.16	3 6 20 27	4
ART- RTA	17	0.10	4 11 18 20	4		12	0.18	16 17 18	3				8 16 21	3
RAT- ATR	7 17 18	0.23 0.10 0.12	6 24 25 29	4		13 18 24	0.11 0.13 0.26	12 22	2				3 7 15 16 21 23	6
RAT- RTA	4	0.15	3 18 24 29	4		3 12 18 24	0.19 0.12 0.13 0.20	17 25	2		3 7	0.46 0.13	8 9 17	3
ATR- RTA	25	0.10	7 17 20 26	4		10 11 17 22	0.20 0.14 0.24 0.10	3 7 20	3		3 8	0.11 0.12	16 21	2

TABLE E-8

Subject JU

	P_4					O_1					O_2			
	F	D	F	#		F	D	F	#		F	D	F	#
ART- RAT	2 13	0.62 0.11	11 17 20 23	4				2 10 13 21 23 25 27	7		2 12 13	0.45 0.18 0.20	15 20 25	3
ART- ATR	10 13	0.16 0.19	7 17 24	3		4	0.31	7 12 15 18 20 22 24 28 29	9		1	0.48	2 7 15 22 29	5
ART- RTA	2 8 13	0.22 0.18 0.10	6	1		12 13 15	0.13 0.22 0.10	4 7 14 18 20 21 25 29	8		2 8 12 13 15	0.35 0.11 0.19 0.15 0.11	7 22 23 28 29	5
RAT- ATR	2	0.27	8 10 17 20	4				7 8 10 13 21 23 28 29	8		29	0.17	2 7 13 15 17 20	6
RAT- RTA	2 8	0.26 0.24	4 7 20 23	4		8	0.12	9 21 23 25 29	5		8 29	0.11 0.18	9 15 17 22	4
ATR- RTA	8	0.32	17 23 25	3		2 8	0.27 0.21	15 16 21 28	4		8	0.18	2 12 18	3

APPENDIX F

Reversible Figure Comparisons

Tables F-1 through F-6 give the Fourier frequency components (F, in Hz) at which $\overline{\Sigma 64}$ VERs obtained from two solid wedges and four reversible figure interpretations were different. Difference was determined when the absolute value of the difference between corresponding frequency component amplitudes in two different $\overline{\Sigma 64}$ VERs was greater than the absolute value of the difference between the same corresponding frequency amplitudes in both the first $\overline{\Sigma 32}$ VER and its replication, making up the $\overline{\Sigma 64}$ VER from the first stimulus, and the second $\overline{\Sigma 32}$ VER and its replication, making up the $\overline{\Sigma 64}$ VER from the second stimulus.

The first, second and third sets of columns refer to data obtained from subjects K, JI and JU respectively. The first column labeled "F" under each of the subject labels refers to frequency components at which the absolute value of amplitude differences between $\overline{\Sigma 64}$ VERs from unlike figures were greater than 10% of the error range for that frequency given in Appendix B (error distributions). The columns labeled "D" give the absolute value of component frequency amplitude differences (in microvolts) for frequencies listed in the first column labeled "F" under each subject heading. The column labeled "#" gives the number of frequency components for a particular comparison showing a difference, but below the 10% criterion. (These frequency components are listed in the second column labeled "F" under each of the subject headings.)

The two solid figure and four reversible figure interpretation VERs compared in each table are:

SWT-SWA... solid wedge toward - solid wedge away

SWT-RWT... solid wedge toward - reversible wedge toward

SWA-RWA... solid wedge away - reversible wedge away

RWT-RWA... reversible wedge toward - reversible wedge away

SRSU-SUSD... stairs right side up - stairs upside down

The format of all comparison tables is the same, differing only in electrode position at which the comparisons are made.

TABLE F-1

Electrode Position F_7

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
SWT- SWA	4	0.12	2 7 9 19	4		8	0.40	2 11 22 29	4		1 6 17 23	0.28 0.29 0.10 0.10	8 10 18 20 22 29	6
SWT- RWT	2	0.43	1 3 7 15 17 24	6		2 8	0.41 0.20	18 19 22 23	4		1 5 23	0.49 0.16 0.15	6 9 11 17 18	5
SWA- RWA	2 23	0.33 0.14	1 3 11 13 14 17 20 25	8				8 10 11 22 24	5		1 4 5 7 29	0.52 0.18 0.15 0.13 0.12	12 14 17 18 19 20	6
RWT- RWA	16 23 24	0.17 0.10 0.11	6	1				2 22 23			1 4	0.22 0.26	5 7 9 10 14 16 28 29	8
SRSU- SUSD			18 29	2				10 13 24 25 26 27	6		6 8 13	0.11 0.13 0.12	14 17 19	3

TABLE F-2

Electrode Position F_8

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
SWT- SWA	4 19 21	0.20 0.18 0.21	2 16 17 22 25	5		1	0.83	4 14 25 26	4		27	0.18	2 11 14	3
SWT- RWT	19	0.13	22 29	2		1	1.14	4 10 24 25 29	5		3 11 13 27	0.12 0.14 0.10 0.19	1 2 16 20 23 29	6
SWA- RWA	2 4 20	0.31 0.19 0.21	16 17 22 28	4		28	0.10	7 20 21 22	4		3 18	0.13 0.21	9 10 20 27	4
RWT- RWA	20 22	0.13 0.17	4 9 13	3				24 28 29	3		6	0.15	3 9 11 19 20	5
SRSU- SUSD	3 5 8 15 20	0.56 0.11 0.21 0.20 0.14	0			9	0.25	2 7 8 10 21	5		27	0.14	7 11 14 21	4

TABLE F-3

Electrode Position P_3

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
SWT- SWA			12 20 21 24 25	5		2	0.57	7 11 12 14 15 20 25	7		1	0.32	2 5 7 8 11 14 23 29	8
SWT- RWT	5 6	0.19 0.11	19	1				4 7 19 27	4		1	0.61	6 7 9 20 29	5
SWA- RWA	11 22	0.20 0.11	3 15 21 23	4		2	0.34	4 6 12 20 26 27 28	7		22	0.10	8 14 21 25 29	5
RWT- RWA	10	0.17	19 22 23 26 27 28	6		14	0.10	7 8 9 10 19 25 26 28	8				21 22 26 29	4
SRSU- SUSD	7 8	0.17 0.15	6 10 11 23 28	5				4 18	2		1 3	0.85 0.13	5 12 13 15 16 27 28	7

TABLE F-4

Electrode Position P_4

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
SWT- SWA	6 14	0.28 0.12	21	1		4	0.24	6 18 20	3		7 18	0.21 0.12	6 8 13 16	4
SWT- RWT	4 6	0.66 0.26	14 19 23 25	4		4	0.29	2 3 24 25	4		1	0.23	7 11 12 14 17 19 24 25	8
SWA- RWA	2 4 27	0.29 0.41 0.11	6 7 9 14 23	5		17	0.18	6 11 13	3		16	0.14	6 8 10 13 17 18 20 25	8
RWT- RWA			7 25	2		17	0.17	5 13 14	3				2 19 20 24	4
SRSU- SUSD	7	0.28	4 5 9 12 16 28	6		5 7 15 16 17 24	0.14 0.15 0.10 0.26 0.11 0.15	1 6 12 23 25	5		1	0.42	11 17 19	3

TABLE F-5

Electrode Position 01

	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
SWT- SWA	2 14 24	0.56 0.13 0.19		0		5	0.21	13 16 25 28	4		5	0.15	1 6 12 14 19	5
SWT- RWT	3 4 11	0.87 0.35 0.34	15 19 22 26	4		4	0.14	11 13 28	3		7	0.15	6 9 14 19 29	5
SWA- RWA	24	0.16	2 4 5 10 21	5				10 13 17 20 26	5		6 18 19	0.11 0.16 0.12	9	1
RWT- RWA	3 28	0.39 0.11	2 4 16 19 21 26	6		5	0.23	10 13 19 25	4		2 6 10	0.20 0.14 0.11	1 8 9 17	4
SRSU- SUSD	14	0.18	9 10 13 17 21	5		4 12 23 28	0.16 0.21 0.15 0.11	3 7 13 27 29	5				1 3 7 10 11 12 23 29	8

TABLE F-6

Electrode Position 02

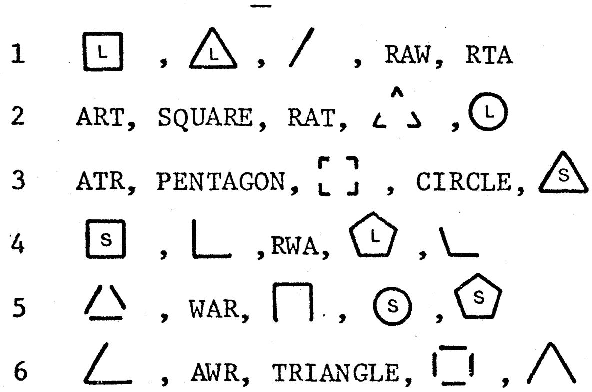
	K					JI					JU			
	F	D	F	#		F	D	F	#		F	D	F	#
SWT- SWA	6 24	0.20 0.10	4 14 26	3		5	0.25	15 25 27	3		5 18 24	0.12 0.16 0.10	27	1
SWT- RWT	3 4 11	0.65 0.78 0.22	6 7 16 26 27 28	6				13 26 27	3		9 25	0.12 0.10	3 5 7 8 10 13 17 19	8
SWA- RWA	4	0.28	3 6 7 10 24	5		2 4 26	0.28 0.21 0.10	14 17 19 22 27	5		18	0.14	6 16 19 24 27 28	6
RWT- RWA	3 4 7	0.36 0.20 0.22	8 11 25 27	4		4	0.15	9 14 17 19 22 27	6		8 10	0.17 0.16	9 13 18	3
SRSU- SUSD	10	0.53	3 14 15 16 23 25	6		4 23	0.19 0.11	13 16 25 28	4				22	1

APPENDIX G

Stimuli

VER data in this study were obtained from four control stimuli, four small geometrical figures, four large geometrical figures, four geometrical figure names, six meaningful trigrams, six nonsense trigrams, fifteen large geometrical figure features, two solid figures, and four reversible figure interpretations. The four control stimuli blank, background only, flash + (background onset), flash - (background offset) and one large geometrical figure feature (for subjects K and JU; for subject JI) were presented during each of four control sessions. Thirty stimuli were chosen from the geometrical figures, geometrical figure names, trigrams, and geometrical figure features forming a stimulus pool for each subject. Stimuli to be used during the first six experimental recording sessions for each subject were chosen randomly from each pool of thirty, five at a time without replacement. Each set of five stimuli were presented during one session. Stimuli to be used in a second set of six sessions for each subject (replicating the first six) were selected from the same stimulus pools in the same way. The stimuli presented to each subject during each session are listed below:

<u>K</u>



7 WAR, TRIANGLE, , ,

8 , , PENTAGON, ART,

9 , , , , RAT

10 RWA, ATR, , SQUARE,

11 RTA, , AWR, ,

12 , RAW, , CIRCLE,

JU

1 , , , CIRCLE, ART

2 , TRIANGLE, , , RAT

3 , , , ATR, RAW

4 , , SQUARE, , RTA

5 , RWA, , AWR,

6 , PENTAGON, , , WAR

7 SQUARE, , , , RAW

8 PENTAGON, , , , WAR

9 , , CIRCLE, RTA, ART

10 RWA, RAT, , ,

11 TRIANGLE, , AWR, ,

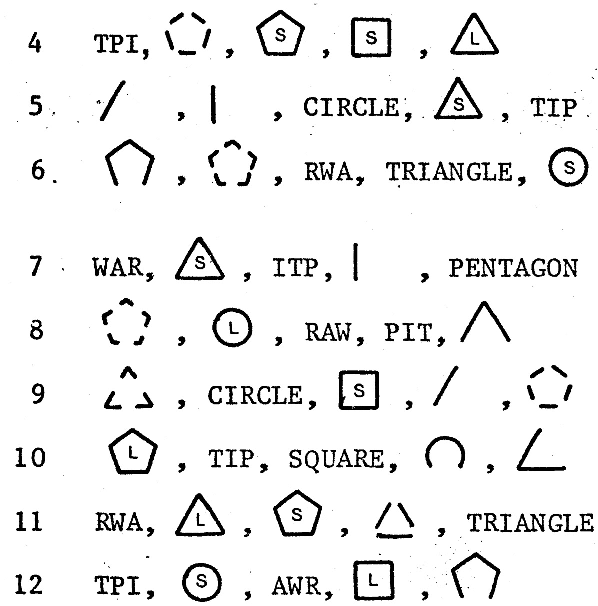
12 , , , ATR,

JI

1 , WAR, , PENTAGON,

2 AWR, , , PIT, SQUARE

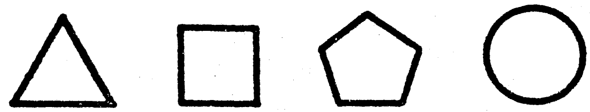
3 , RAW, , , ITP



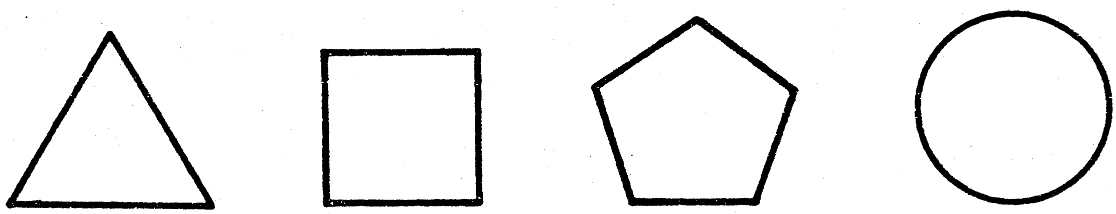
The following stimuli were all presented to every subject during each of eight recording sessions: the two solid figures (a solid wedge with the sharp edge viewed as toward the subject and a solid wedge viewed as away from the subject), and four reversible figure interpretations (reversible wedge with the sharp edge interpreted as toward the subject, reversible wedge toward; reversible wedge interpreted as away from the subject, reversible wedge away; reversible staircase interpreted as right side up, viewed from the top; reversible staircase interpreted as upside down, viewed from the bottom).

The stimuli are shown on the following pages grouped according to stimulus class. They are shown in correct proportion to one another. Data from underlined stimuli were analyzed in this study.

SMALL GEOMETRICAL FIGURES



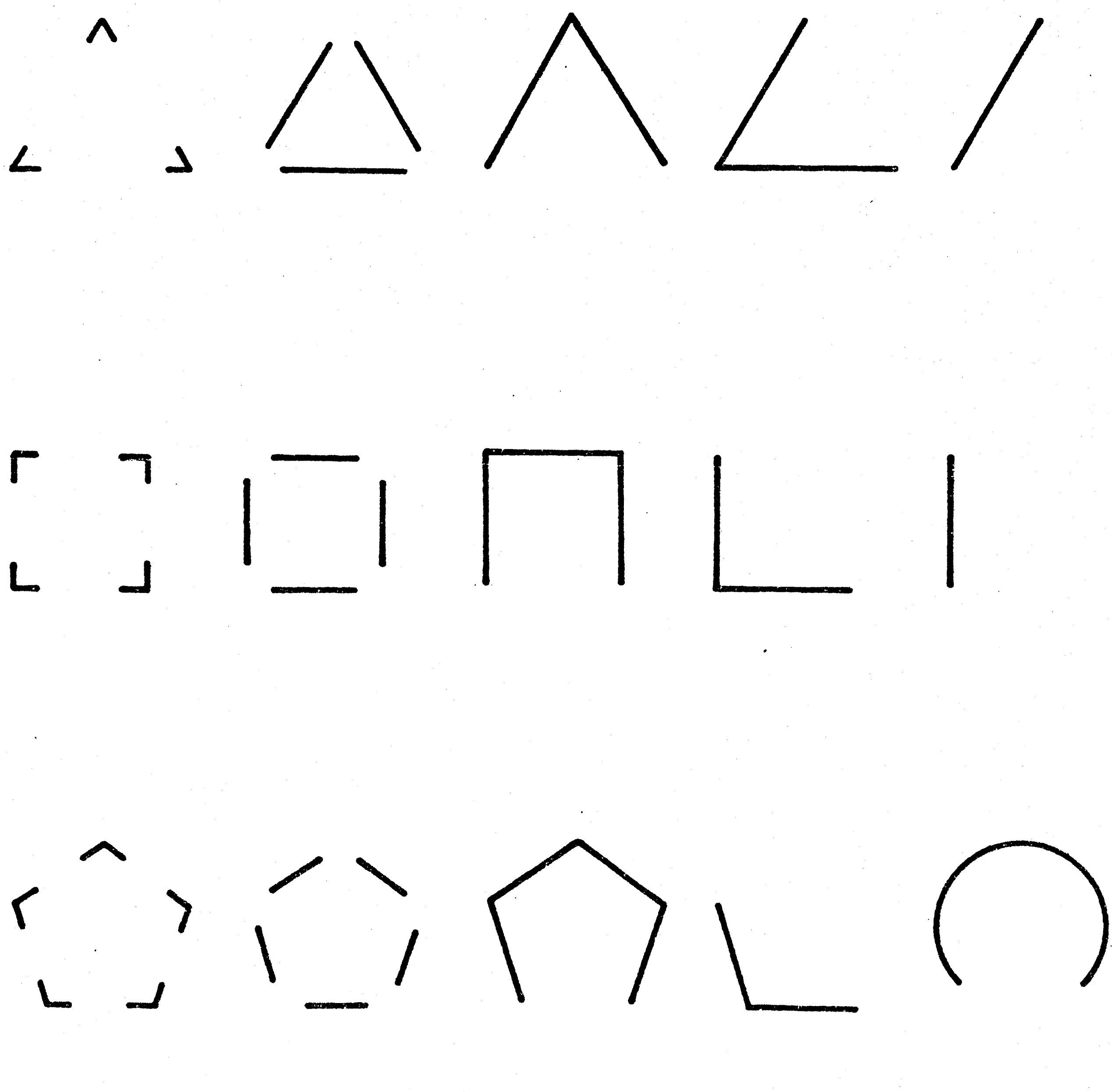
LARGE GEOMETRICAL FIGURES



GEOMETRICAL FIGURE NAMES

TRIANGLE   SQUARE   PENTAGON   CIRCLE

GEOMETRICAL FIGURE FEATURES



MEANINGFUL TRIGRAMS

WAR RAW

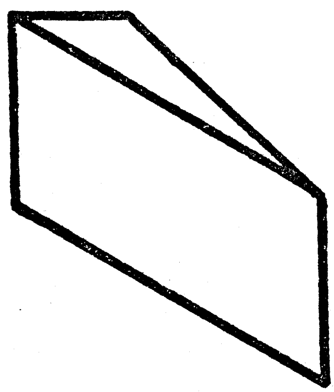
RAT ART TIP PIT

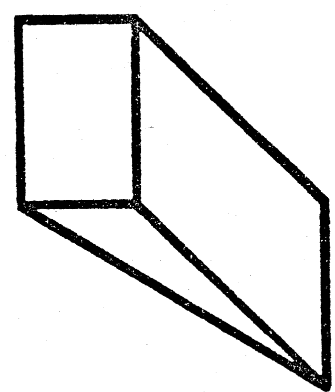
NONSENSE TRIGRAMS

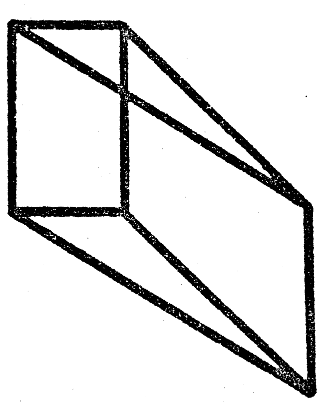
AWR RWA

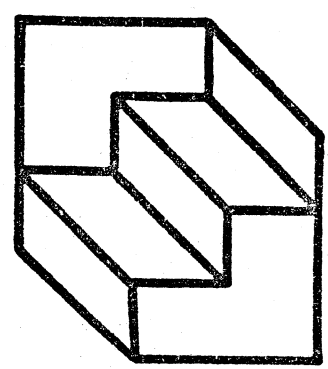
RTA ATR TPI ITP

SOLID AND REVERSIBLE FIGURES









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